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JOURNAL OF PALEONTOLOGY

JOSEPH A. CUSHMAN, Editor

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JOURNAL OF PALEONTOLOGY

SEPTEMBER 1929

STRATIGRAPHY AND FAUNA OF THE LUTA LIMESTONE (PERMIAN) OF OKLAHOMA AND KANSAS

By MARGARET FULLER BOOS
Bartlesville, Oklahoma

INTRODUCTION

The Luta limestone is the basal member of the Sumner group in the Lower Permian of Kansas and northern Oklahoma. Outcrops extend in a general north to south direction through central Kansas and north central Oklahoma dipping at a low angle to the southwest. The fauna is typical of that of the latest Paleozoic, showing a marked decline in species of Brachiopoda, Trilobita, Crinoidea and Anthozoa and an increase in the mollusca particularly Pelecypoda.

This study is a preliminary report of work which will include tracing the Luta northward into Nebraska. Acknowledgements and sincere thanks are extended to Professors U. S. Grant and R. C. Moore for the use of the libraries of Northwestern University and University of Kansas respectively and to Dr. C. N. Gould for the photographic facilities of the Oklahoma State Geological Survey. Professor C. O. Dunbar gave valuable suggestions in the problems of identification and Dr. Matt Hill loaned his private collection of Luta forms.

STRATIGRAPHY

The Luta limestone was first recognized as the basal bed deposited during the Marion stage of the Kansas Permian.[1] More recently the Luta together with the Enterprise, Herington and Wellington beds have been classified under the Sumner group. In the legend of the geologic map of Cowley County, Kansas, the following section is given

Cowley County, Kansas[2]

Sumner group	Wellington formation
	Herington limestone
	Enterprise shale including the Luta limestone member at the base
Chase group	Winfield limestone
	Doyle shale, etc.

The state Geologic map of Oklahoma does not differentiate the Luta but includes it under the Marion formation.

Legend for North Central Oklahoma[3]

Sumner group	Wellington formation
	Marion formation (Herington limestone member only mapped)
Chase group	Winfield limestone
	Doyle shale, etc.

The Luta limestone has been traced by almost continuous outcrop from south to north across Kay County, Oklahoma, Cowley County, Kansas and, with interruptions, across most of Butler County, Kansas. Figure 1. Some seventy sections and collection localities have been identified.

The Luta rests conformably with a slightly irregular contact on the Winfield limestone. Figure 2. It outcrops in ledges twelve to eighteen feet thick at the heads of ravines above cliffs of massive Winfield limestone. To the casual observer the Luta appears to be a thinbedded upper member of the Winfield limestone, an error which leads to local discrepancies in well log correlations. Certain differences between the two formations are outstanding. 1. The Luta is a densely crystalline to earthy limestone in which are embedded lenses and layers of well preserved fossils. The Winfield limestone is granular and marked by minute fragments of fossils. 2. The Luta is an irregularly platy, white to gray limestone interbedded with gray limy shale and, in Oklahoma, is locally arenaceous. The Winfield consists mostly of two massive gray to buff limestone beds.

[1] Beede, J. W., Formations of the Marion stage of the Kansas Permian. Kansas Acad. Sci. Trans., vol. 22, 1908, p. 248.
[2] Kansas Geological Survey Bull. 12, pl. 1 (pl. 1 only has been published).
[3] Geologic map of Oklahoma compiled by Hugh D. Miser, 1926.

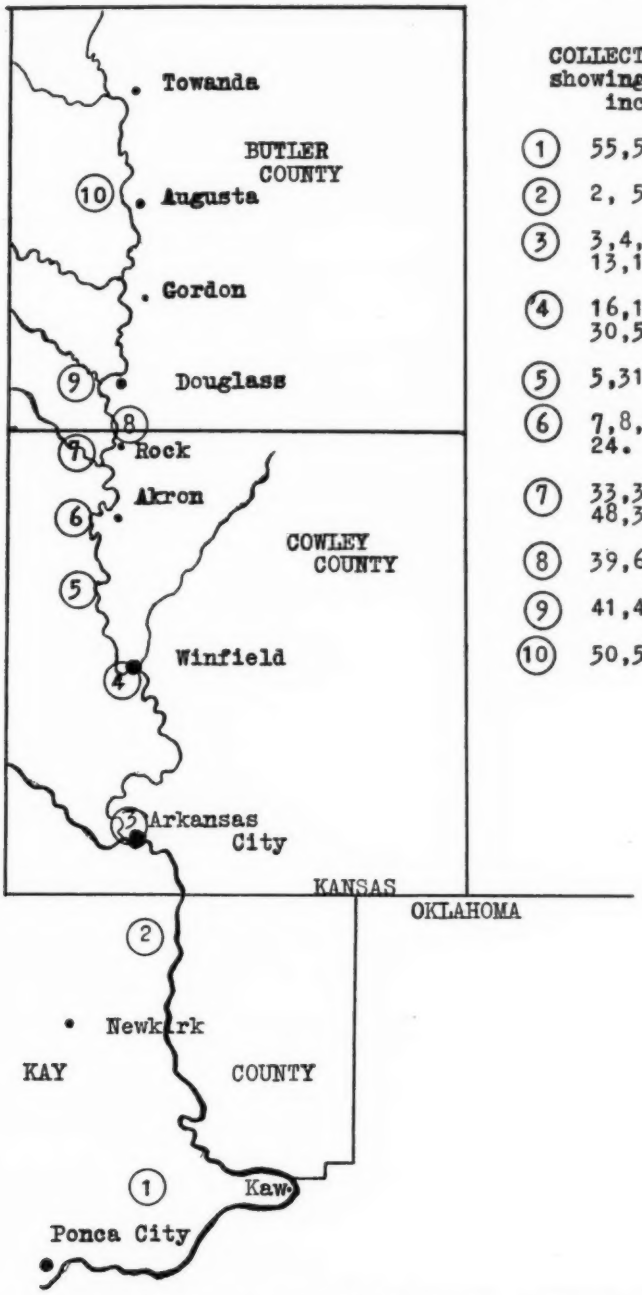


FIG. 1.—Sketch map to show collecting areas in Kansas and Oklahoma, with stations included in each area.

From Winfield, Kansas, to Ponca City, Oklahoma, the base of the Luta is marked by six to twelve inches of limestone packed with well preserved *Septopora biserialis, Archeocidaris trudifer, Delocrinus hemisphericus, Derbya cymbula,* and *Composita subtilita.* Most outcrops from Butler County southward, as far as the Luta is known, show three or four feet of massive limestone above the basal bed with scattered *Myalina permiana, Myalina copei, M. recurvirostris, Derbya cymbula* and numerous concretions and a few geodes. Middle beds show thin lenses and layers of *Derbya cymbula, D. broadheadi,*

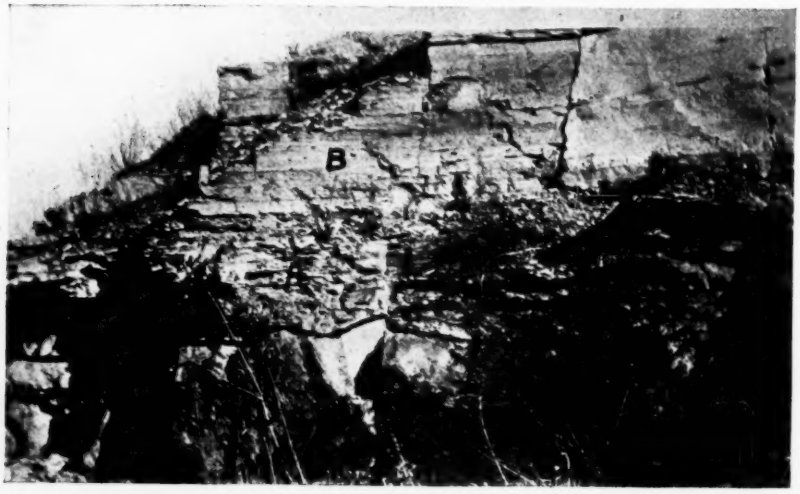


Fig. 2.—Photograph of an outcrop west of Winfield, Kansas (Station 58). W is the upper bed of the Winfield limestone, the black line follows the contact of the Winfield and the Luta, and A is the lower platy limestone of the Luta overlain by B, the massive middle beds of the Luta.

and *Composita subtilita* with exposed ledges marked by fossil pavements. Commonly above the middle occurs thin gray to black limy shales, rarely exposed but where observed marked by *Myalina copei, Pseudomonotis hawni, Deltopecten occidentalis, Aviculopinna* sp., *Pinna, Astartella concentrica, Pleurophorus* sp., and rare but well preserved *Delocrinus conicus* and *D. hemisphericus. Lingula* cf., *carbonaria, Orbiculoidea convexa, O. missouriensis, Crania modesta* and *Crania* sp. occur at the same horizon.

The top of the Luta limestone in Cowley County, Kansas, is marked by six inches of platy, white limestone full of small mollusca, *Holopea parvulus* predominating. This layer marks an horizon identifiable in well cuttings. Locally the top of the Luta is barren of fossils and

streaked with layers and masses of brown chert. North of Cowley County the Luta limestone is buff in color, the intensity of the buff color increasing to the north. It retains its platy character but fossils are rare except in the basal part.

FAUNA

Species identified and their geographic distribution are indicated in figure 3. The Brachiopoda, although few in species, outnumber all other orders in abundance of individuals. Thousands of *Composita subtilita* are crowded in thin layers, the individuals being smaller than those found lower down in the Permian or in the uppermost Pennsylvanian beds. Masses of *Derbya cymbula* and *D. broadheadi* are crowded and nested in layers a few inches thick. Among some two thousand specimens of *Derbya* collected from the Luta there are all possible mutations from *D. robusta* through *cymbula, broadheadi* to *bennetti.* Typical *D. crassa* is not known but there are many individuals like *crassa* but larger, more gibbous and having less pronounced plications. It is doubtful if *Productus semireticulatus* occurs in the Luta but *P. calhounianus* is represented by numerous well preserved casts and shells.

The Pelecypoda are represented by more species than any other order but individuals are rarely preserved and appear to have had thin shells in many cases. *Myalina copei* is fairly common and appears to be confined to the Luta in the region studied. Gastropoda and Cephalopods are rare and poorly preserved.

Phillipsia major seems to be the last of the trilobites. Locally pygidia occur near the top of the Luta.

DESCRIPTION OF NEW SPECIES

ECHINODERMATA

CRINOIDEA

Family POTERIOCRINIDAE

Genus DELOCRINUS Miller and Gurley

DELOCRINUS CONICUS, n. sp.
Plate 27, figs. 1, 1A, 1B, 1D

Description.—Calyx fairly deep, conical basin-shaped. Three to three and a half centimeters in diameter and about two centimeters high. Underside concave with base pushed up one third of way into body. Outline of calyx circular or slightly oval viewed from either

species	localities (see figure 1 for stations included under each locality)									
	1	2	3	4	5	6	7	8	9	10
Anthozoa										
Lophophyllum profundum				R						
Echinozoa										
Archeocidaris trudifer	R		C	C		C	C			
Archeocidaris cowleyi n.sp.			A					A		
Crinoidea										
Delocrinus conicus n.sp.				C			R			
Delocrinus hemisphericus	R			C		R	R	R		
Erisocrinus lutana n. sp.				R			R			
Bryozoa										
Fenestella sp	R	R	R	C	R	C	R	R	R	R
Rhombopora lepidendroidea	R		A	C	C	C	R	R	C	R
Rhombopora sp		C						R		
Septopora biserialis	C	C	A	C	C	C	C	R	C	C
Stenopora tuberculata	C		C	R					R	
Brachiopoda										
Composita subtilita	C	C	C	A	C	A	C	A	C	C
Crania modesta	R			C	R		R	A		
Derbya bennetti			R		R		R			
Derbya broadheadi	R	R	C	C	R	C	R	R		
Derbya crassa ?			C	C		C				
Derbya cymbula	R	C	C	C	R					
Derbya robusta	R		R	R						
Lingula cf.batesvillae				R						
Orbiculoidea convexa				R						
Orbiculoidea missouriensis				R	R		R			
Productus calhounianus	C	C	A	A	C	C	C	C	R	
Productus costatus ?				R						
Productus sp				R						
Vermes										
Spirorbis sp 1		C		C	R		R			
Spirorbis sp 2			R		R					
Pelecypoda										
Allerisma subcuneatum	R						R	R		
Allerisma teminale				R				R		
Astartella concentrica				R		R	R			

species	localities (see figure 1 for stations included under each locality)									
	1	2	3	4	5	6	7	8	9	10
Pelecypoda (continued)										
Aviculopinna illinoisensis				R		R			R	
Deltopecten occidentalis	C		R	C		C	R	C	R	
Edmondia aspenwallensis				R						
Edmondia gibbosa				R						
Lithophaga pertenuis			R							
Myalina copei	C	C	C	A	R	C	C	R	R	
Myalina kansasensis	R		R	C						
Myalina perattenuata	R		R	C						
Myalina permiana	C	R	R	C			R			
Myalina recurvirostris	C	R	R	C		R	R		R	
Myalina swallovi	R		R							
Nuculopsis ventricosa	R			R						
Placunopsis carbonaria	R			R		R	R		R	
Pinna peracuta	R			R		R				
Pleurophorus sp				R						
Pseudomonotis hawni	R					R			R	
Schizodus wheeleri	C			R						
Schizodus sp	R					R				
Yoldia subscitula	R							C		
Posodonia sp				R						
Gastropoda										
Euomphalus subquadrata				C						
Conularia sp				R						
Holopea parvulus n.sp.				A						
Sphaerodoma sp				R						
Cephalopoda										
Metacoceras cornutum	R		R		R		R	R		
Nautilus forbesianus				R						
Temnocheilus winslowi	R			R						
Nautilus sp	R			R		R				
Orthoceras sp		R				R				
Trilobita										
Phillipsia major			R	R		R				
Pisces										
3 species fish teeth				R						
Fucoid										
Branching alga	C			C						

Fig. 3.—Fauna of the Luta limestone.

above or below, the walls straight or slightly flaring at the superior margin of radial plates, the whole wall inclined to the plane of the base about 115 degrees. Plates smooth, thick, stout and nearly five mm. through at summit of radials. All plates meet flush with smooth unfurrowed suture.

Infrabasal plates obscured by column facet, well pushed up in the base of the calyx, smooth on the inside and marked by slight pucker at interior summit. See figure 1A, plate 1. Basal plates five, longer than wide as measured from the suture with the infrabasal out of the depressed base to junction with radial plate. Radial plates five, pentagonal, slightly obliquely faceted and milled at superior edge for reception of base of first costal. Area of basal plate nearly that of radial. Anal plate rests upon truncated basal plate and between two radials so that it extends above the superior limits of the adjoining radials one third of its length. This first anal plate is concave at the rim of the cup and bent inward above it at a sharp angle. It bears on its somewhat constricted edge an apparently rectangular second anal plate. The first costal is smooth, convex and without spine processes. It is wider than high, pentagonal and bears two rectangular second costals at the summit. Upper costals and pinnules unknown.

	Width	Height
Basals	13 mm.	9 mm. outside basal
Radials	12 mm.	10 mm. cavity
Costals	13 mm.	7 mm.
1st anal	6 mm.	9 mm.
2nd anal	4 mm.	4 mm.

Range and Distribution.—Sumner group, Luta limestone, from Ponca City, Oklahoma, northward to Towanda, Kansas.

This species may be distinguished from *D. hemisphericus* with which it is associated in the Luta by its greater size, deep calyx, straight or slightly flaring walls, convex costals and concave inward bent anal plates.

Genus ERISOCRINUS White

ERISOCRINUS LUTANA, n. sp.

Plate 27, figs. 2, 2A, 2B, 2C, 2D

Description.—Calyx small, less than eight mm. in diameter, about 2 mm. deep and basin shaped. Plates thick and ornamented with granulations in more or less coalescent rows giving a faintly pebbled labyrinthine appearance to the surface. Infrabasals covered by the

base of column, segments of which are about 3 mm. in diameter. Basals large, strongly convex and joined along a marked suture furrow, all pentagonal, equal in size, as wide as high, and the apical angle of the basal plates extends up between the radials one third of the height of the radial plates. Radials five, equal, pentagonal, thick, convex, one third wider than high and slightly beveled at upper edge with the milled facet and the first costal meeting along a gaping articulation. Costals five, constricted in the middle to a slender shaft, broad milled facet at base, widened at upper surface to support two rows of distichals which are quadrangular in crossection. Arms square and branching at least twice. Pinnules not known.

The small size of this species and the slender shaft of the first costal distinguish it from other species. Individuals are rare near Winfield in the shaly black limestone two feet above the base of the Luta.

Range and Distribution.—Sumner group, Luta limestone, Winfield, Kansas. Collected from stations 18 and 48.

ECHINOIDEA

Family ARCHEOCIDARIDAE

Genus ARCHEOCIDARIS McCoy

ARCHEOCIDARIS COWLEYI, n. sp.
Plate 27, figs. 3, 3A, 3B, 3C

Description.—Species known from several crushed tests and isolated spines and plates. The body is one half inch to two inches in diameter and apparently spherical. Interambulacral plates broad, thick, stout, and with an elevated border marked by tubercles. The central mamelon or tubercle is small, perforated, and projects above the surrounding broad, elevated ring which forms a shallow cup around the central tubercle. The base of the ring rests on a slightly pyriform platform into which it merges. The plates resemble *A. agassizi* except that in *agassizi* the central tubercle is in a quite deep cup. *A. trudifer* is like this species but has an additional, slightly raised ring in the cup between the tubercle and the annulation on the boss.

The spines are slender, longest measuring two inches from base to tip and all have a slightly bulbous, basal ring marking the widest part of the spine which extends up into a slender, hollow shaft tapering to a somewhat blunt tip. Short, slender spinules occur in alternate position at regular intervals, the distance from the basal ring to the first spinule being about that between the distal ones.

Weathered spines appear regularly segmented with spinules at the joints. The spines are like *A. trudifer* but are shorter, less terete, and have alternate rather than spirally arranged spinules.

Range and Distribution.—Sumner group, Luta limestone, from top to bottom of beds. Ponca City, Oklahoma to Towanda, Kansas.

EXPLANATION OF PLATE 27

Delocrinus conicus, n. sp.

FIG. 1.—Sketch of profile of calyx showing, in particular, the first and second costals. Calyx broken at base. (×½.) Station 18.

1A.—Photograph of the interior sides of the infrabasal plates which form an invaginated cone within the base of the calyx. (×1.)

1B.—Sketch of the type specimen showing calyx in profile. Note straight sides and flat sutures. (×½.)

1C.—Calyx of *D. hemisphericus* sketched in profile for comparison with similar view of *D. conicus* in 1B. (×½.) Station 18.

1D.—Photograph of weathered vertical section through the stem, calyx and part of the arms of *D. hemisphericus*. Note the deeply concave base, the rounded outline and the delicate pinnules. (×½.) Station 14.

Erisocrinus lutana, n. sp.

FIG. 2.—Basal view of calyx and outspread arms. (×1.)

2A.—Side view of calyx believed to belong to this species but having a slightly flattened calyx. Note the characteristic first costals. (×1.) Station 18.

2B.—Photograph of calyx from below. (×1.) Station 18.

2C.—Sketch of calyx as flattened from below. (×1.)

2D.—Sketch (×2) of radial and costal plates.

Archeocidaris cowleyi, n. sp.

FIG. 3.—Sketch of a slightly diagonal section through an interambulacral plate and the attendant spine to show spinules. (×2.)

3A.—Base of spine. (×1.)

3B.—Profile of interambulacral plate. (×1.)

3C.—Two small flattened tests each about an inch across. Normally the bodies of *A. cowleyi* must have reached a diameter of two to four inches. Station 1.

Productus calhounianus Shumard

FIG. 4.—Sketch of ventral view with the numerous spines and tubular spine bases together with the irregular costae. (×1.)

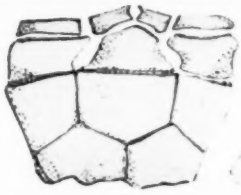
4A.—Side view of a somewhat exfoliated specimen. (×1.)

4B.—Dorsal view showing the narrow pointed beak. The black triangles show the outline of the margins of the otherwise broken ears. (×1.) Station 18.

Holopea parvulus, n. sp.

FIG. 5.—Photograph of a fragment of the Luta limestone with many casts of this species. (×½.) Station 18.

(Photographs by Dr. Ray Six through courtesy of the Oklahoma Geological Survey.)


1

1A

1B

1C

1D

3

3A

3B

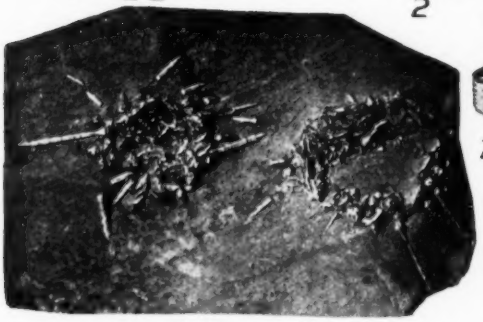
5

2C

2A

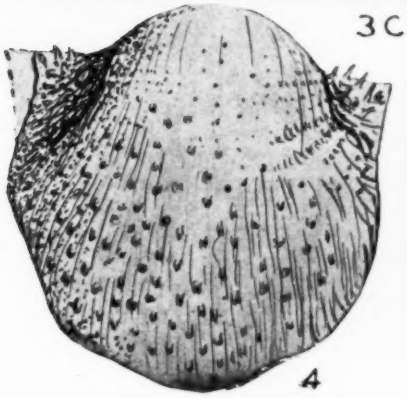
2B

2


3C

2D

4A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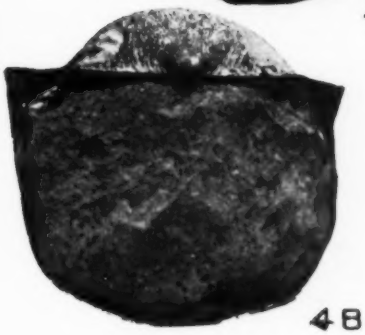
4B

GASTROPODA

Family PYRAMIDELLIDAE

Genus HOLOPEA Hall?

HOLOPEA PARVULUS, n. sp.

Plate 27, fig. 5

Description.—Height about 9—10 mm., greatest diameter 5 mm., largest volution 2 mm. high. Commonly five whorls well rounded and smooth. Known only from casts. Sutures deep and whorls taper gradually.

Following Girty these specimens have been designated as of the genus *Holopea* instead of *Loxonema* since they appear to be devoid of sculpture on the whorls.[4]

Holopea parvulus is confined to the uppermost layer of the Luta and serves as a marker wherever exposed. It has been recognized in well cuttings.

Horizon and Locality.—Sumner group, Luta limestone, upper six inches. Stations 18 and 65.

[4] Girty, G. H., "Fauna of the Wewoka Formation of Oklahoma", U. S. G. S. Bull. 544, p. 185, 1915.

OTHER SPECIES FIGURED

BRACHIOPODA

Family PRODUCTIDAE

Genus PRODUCTUS Sowerby

PRODUCTUS CALHOUNIANUS Swallow

Plate 27, figs. 4, 4A, 4B

Productus calhounianus SWALLOW, Trans. St. Louis Acad. Sci., vol. 1, 1858, p. 181, p. 215. (Lower Permian, Kansas. Upper coal measures and Permian, Kansas.)

Productus calhounianus SHUMARD, Trans. St. Louis Acad. Sci., vol. 1, 1859, p. 389. (White and Dark Permian limestone, Guadaloupe Mts.)

Productus calhounianus MEEK and HAYDEN, Proc. Phil. Acad. Sci., 1859, p. 26. (Upper Coal Measures: Fort Riley and Cottonwood Creek, Kansas.)

Productus calhounianus NEWBERRY, Ives' Colorado Expedition, 1861, p. 123. (Carboniferous: Kansas.)

Productus semireticulatus, var. *calhounianus* PROSSER, Kansas Univ. Quarterly, vol. 6, no. 4, 1897, p. 149. (Permian and Upper Carboniferous of southern Kansas.)

Swallow's original description: "Shell large, subhemispherical; *sinus* narrow, extending from the visceral region to the anterior border of the dorsal valve; *beak* small, recurved beyond and within the cardinal border; *ears* large, triangular, strongly arched, curving towards the cardinal border, ornamented

with numerous tubular spines, those on the cardinal border somewhat regularly arranged in rows; *Cardinal border* as long as the greatest width of the shell, the extremities somewhat reflexed towards the visceral region of the dorsal valve; *dorsal valve* regularly arched, with a curve constantly increasing from the anterior border to the beak, ornamented with numerous somewhat irregular longitudinal costae, narrow and prominent towards the beak but broader and more flattened towards the anterior margin, their number increasing by insertion and subdivision; the whole surface ornamented by tubular spines, which are more numerous towards the borders and on the ears, and usually spring from the costae; visceral region for a short distance from the beak marked with irregular, concentric, waving, more or less prominent rugae; *Ventral valve* strongly arched, slightly flattened on the visceral region and towards the anterior margin, ornamented with costae and rugae; *mesial ridge* corresponding to the dorsal sinus; *internal surface* of ventral valve garnished with a prominent trifid *cardinal process* fortified at its base with three divergent ridges, two extending laterally nearly parallel to the cardinal line and becoming nearly obsolete on the ears; the third or mesial ridge extends perpendicularly from the cardinal border to the middle of the valve, where it becomes prominent and sharp; on each side of the last and in the angles between it and the two former ridges are the ovate rugose scars of the *adductor muscles; vascular impressions* ovate near the anterior and lateral borders, connected by recurved sinuses to the anterior part of the mesial ridge; *central portion* of the visceral region punctate and marked with longitudinal costae; around the anterior border is a zone, ornamented with tubes, those on the interior portion large and prominent while those nearer the border are small, depressed, and more numerous; interior of the dorsal valve marked with oblong elliptical rugose *adductor muscle scars* separated by a deep narrow longitudinal sinus."

Length from beak to anterior border, 1.65 inches; breadth 2.25; height of dorsal valve 1.15.

P. calhounianus is very common all through the Luta and as far as observed in the region studied is confined to the Lower Permian. It is almost the only Productid in the Luta limestone. The numerous tubular spines, the irregular costae, and the narrow beak distinguish it from *P. semireticulatus*, which it most nearly resembles. As far as is known it is here figured for the first time.

Range and Distribution.—Sumner group, Luta limestone, from Ponca City, Oklahoma, northward to Marion, Kansas. Common from top to bottom of the Luta.

FISH OTOLITHS, THEIR OCCURRENCE AND VALUE AS STRATIGRAPHIC MARKERS

By ROBERT B. CAMPBELL
Consulting Geologist, San Angelo, Texas

INTRODUCTORY

The micro-examination of Upper Cretaceous and Tertiary deposits frequently reveals small concretions of carbonate of lime not unlike seeds and which show definite sculpturing. These are easily recognized as "fish otoliths" or "ear-stones". However an examination of American geologic and paleontologic literature indicates that they have been almost totally ignored by workers in the field of stratigraphy. This paper includes a discussion of the otoliths themselves, their value in correlation, Koken's description of twenty-three species from America and an extensive bibliography with lists of otoliths discussed.[1] These latter data are included as control for conclusions drawn and to afford a point of departure for future work in this interesting field now lying fallow.

As in the case with many fossilized forms we find that Aristotle, Pliny, and other Greek and Roman scholars were familiar with the otoliths of fishes. They contented themselves with noting their occurrence. Characteristically during the Middle Ages these fossils were regarded with superstition and they were frequently borne as amulets. Some, called St. Peter's Stones because they bore the imprint of St. Peter's keys, were comparatively recently to be found in apothecary shops. In this connection they were used as a preventative and cure for colic and headache.

Even after these otoliths began to be studied by men of science strange ideas concerning them were entertained. It was even the

[1] This bibliography with the attached list of otoliths discussed has been prepared in mimeograph form and may be had from the Secretary on request.

opinion of some that these stones in the heads of fishes frequently brought about their death by attracting the cold in winter thereby causing their brains to freeze. Gradually more tenable explanations were offered and it was recognized that there was some connection with the hearing of fishes, the existence of which sense had hitherto been denied.

Klein (1740) showed the existence of otoliths in thirty fish and was of the opinion that these otoliths corresponded to the little bones found in the ears of higher vertebrates (Hammer, Anvil and Stirrup). This view, elaborated by Geoffroy St. Hilaire, was adhered to down to Cuvier's time. Though Cuvier occupied himself but little with fish otoliths he ascertained that they have nothing to do with bones but consist of carbonate of lime and in their internal structure resemble the shells of the Lamellibranchiata. He also regarded them as having excellent characteristics for the differentiation of species and emphasized the presence and formation of the sulcus as the most significant characteristic of the otolith.

During the ensuing years frequent learned works appeared concerning the hearing of vertebrates, but unfortunately the otoliths were mentioned only in passing. Where mentioned they were not even then made use of in the science of paleontology or stratigraphy until in 1884 Professor Ernst Koken of Berlin published his "Ueber Fisch-Otolithen, insbesondere über diejenigen der norddeutschen Oligocän-Ablagerungen". In this paper he discussed fish otoliths in general, describing thirty-three otoliths from living fishes and twenty-three from the North German Oligocene deposits. Subsequently (1888) he described twenty-three species from the Claiborne, Jackson and Vicksburg of Mississippi and Alabama. Their occurrence is as follows:

	Claiborne	Jackson	Vicksburg
Otolithus (Carangidarum) americanus	−	+	+
Otolithus (Apogonidarum) hospes	−	+	−
Otolithus (Pagelli) elegantulus	−	+	−
Otolithus (Sparidarum) insuetus	−	+	−
Otolithus (Sciaenidarum) radians	−	−	+
Otolithus (Sciaenidarum) gemma	−	+	+
Otolithus (Sciaenidarum) epporectus	−	−	+
Otolithus (Sciaenidarum) claybornensis	+	?+	−
Otolithus (Sciaenidarum) intermedius	+	−	−
Otolithus (Sciaenidarum) similis	−	+	−
Otolithus (Sciaenidarum) dicipiens	+	−	−
Otolithus (Trachini) laevigatus	−	+	−
Otolithus (Cottidarum) sulcatus	−	+	−

Otolithus (Triglae) cor	−	+	−
Otolithus (Cepolae) comes	−	+	−
Otolithus (Mugilidarum) debilis	−	+	−
Otolithus (Gadidarum) Meyeri	−	+	−
Otolithus (Gadidarum) elevatus	+	−	−
Otolithus (Gadidarum) mucronatus	+	−	−
Otolithus (Platessae) sector	+	+	+
Otolithus (Soleae) glaber	−	+	−
Otolithus (Congeris) brevior	−	+	−
Otolithus (inc. sedis) aff. *umbonata*	−	−	+

As far as this writer knows these are the only described species in North America. Koken's descriptions and illustrations of these twenty-three species accompany this paper.

Since Koken the literature has grown mainly with the work of Bassoli in Italy, Priem in France, and Schubert in Austria.

The Otolith

The first difficulty encountered in the description of fossil otoliths was with the nomenclature. Since they are only part of an organ the logical course would have been to name them with reference to the name of the animal in question. But they are rarely found *in situ* or associated with other remains of fish with which they may be associated with certainty. On the contrary they usually occur as isolated bodies and association with living genera is rarely possible. For the most part they may be referred to association only with a known family. For these reasons, Koken adopted the practice of giving them the common name of "*Otolithus*" to which the name of genus or family was added in parentheses as *O. (Gadus) elegans, O. (Berycidarum) major.* This practice is general with students of otoliths.

The otoliths are secreted in a few definite regions of the auditory organ. A small one, termed the lapillus, is formed in a portion of the labyrinth known as the utriculus; a second, termed the asteriscus, is formed in a posterior prolongation of the otolith-sac (sacculus), called the lagena; and a third, the sagitta, which is the principal earstone which occurs in the sacculus. (Fig. 1.) This sagitta is the most important and is by far the largest in most cases.

This sagitta is precisely placed in the sacculus and so may be oriented even in the fossil conditions. Thus the obvious designations are (fig. 2) the dorsal, ventral, frontal and caudal, an outer and inner side. The outer side is generally concave, the inner side always convex. On the convex inner side there is a comparatively long depres-

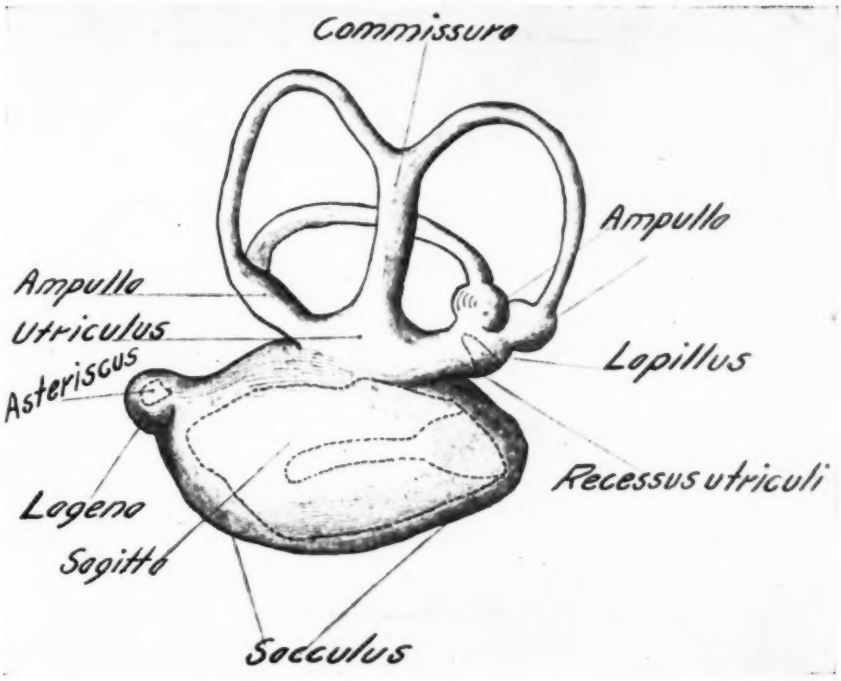
Commissura
Ampulla
Ampulla
Utriculus
Asteriscus
Lapillus
Recessus utriculi
Lagena
Sagitta
Sacculus

Fig. 1

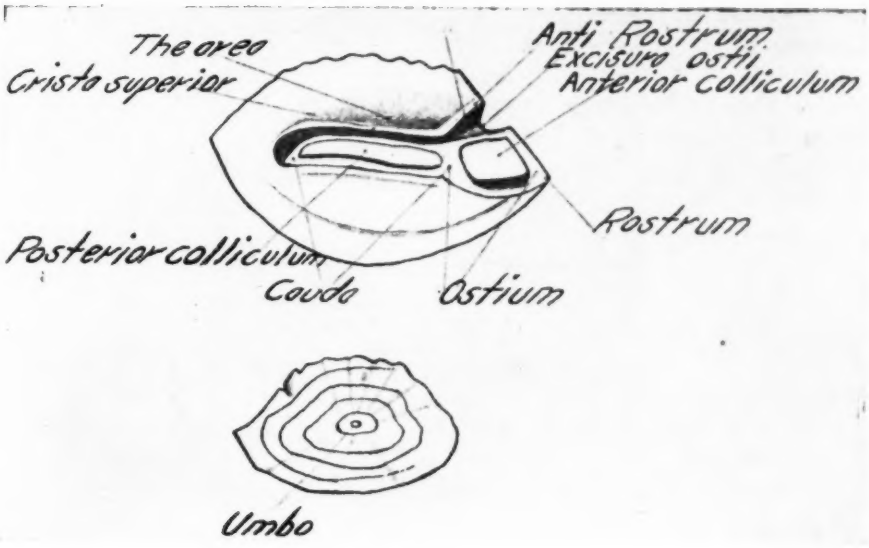
Area
Anti Rostrum
Crista superior
Excisura ostii
Anterior colliculum
Rostrum
Posterior colliculum
Cauda
Ostium
Umbo

Fig. 2

sion running from front to rear which has been named the sulcus acusticus. This is the most important characteristic for all determinations. Usually this is divided into two parts, the frontal one, called the ostium, and a narrower one towards the rear and usually curved downward called the cauda. In most species the ostium and cauda are distinct. The sulcus acusticus is depressed throughout its length but not infrequently there occur small islands termed anterior and posterior collicula. The boundaries of the sulcus are frequently two ridges that unite at the end of the cauda, or in the event that the cauda does not close, either disappear or merge at the caudal edge of the otolith. The upper ridge—crista superior—is the more strongly expressed especially when there is a depression on the face of the otolith. This depression is called the area. Occasionally the area corresponds to a narrow depression on the inner side running parallel to the ventral edge. The frontal boundary of the ostium has on it two projections, the lower—rostrum—much stronger and more pronounced than the upper—antirostrum.

On the usually concave outer side may frequently be observed concentric lines of growth the center of which is raised like a boss—umbo. Two types of sculpture are observable, one radiating and folding, and one with tubercles. The Gadidae and Scaenidae are of the latter type, the Sparidae, Percoidae, etc., of the former. Frequently there also occur combinations of these two types.

In addition attention must be paid to whether the edges are sharp or rounded, thick or thin, indented, crenulated acutely or scalloped. The dorsal edge is usually the more plicated or indented. It is also important to note the size of the otolith for, since it is not usually proportionate to the size of the fish, it may furnish worth-while determining characteristics in special cases.

The Otolith as a Stratigraphic Marker

The above description and indicated systematizing of the otolith suggests its use as a marker in stratigraphy. It is favorably constructed for preservation as a fossil. It can never displace foraminifera in the determination of the age of sediments because of its comparatively rare occurrence but since they are the remains of a free-swimming vertebrate which is much higher in the biologic scale than other fossils usually used for this purpose, these otoliths are admirably suited to be used as a tie between sections located far apart—sections whose comparatively local zones are well studied through foraminifera, ostracoda or other micro-fossils.

DESCRIPTION OF SPECIES FROM THE CLAIBORNE, JACKSON, AND VICKSBURG OF ALABAMA AND MISSISSIPPI

ACANTHOPTERYGII

CARANGIDAE

OTOLITHUS (CARANGIDARUM) AMERICANUS Koken

Plate 28, figs. 1, 3

Length,[1] 4.7 mm.; breadth, 2.5 mm.; thickness, 0.5 mm.

Shape.—Elongated elliptical, cut off short behind diagonally, pointed in front and cut off short only in the region of the ostium for a short distance vertically. The exterior, flat, transverse, concave, traversed by an indistinct longitudinal ridge, only vaguely sculptured.

The sulcus acusticus is divided into cauda, strongly furrowed and bent down sharply behind, and into an elongated ostium which is at times almost spatula—formed, shallower and containing collicula. The ostium projects far and is, as above mentioned, cut off vertically. Excisura ostii is only faintly developed, often hardly indicated, but there always leads from it a distinct secondary furrow below the crista superior to the beginning of the cauda. The crista superior leads to the bend of the cauda where it loses itself. Over it there lies a distinct area. A delicate ventral furrow unites in a wide curve the end of the cauda with the frontal part of the ostium.

Other ornamentations are mostly indistinct and found most frequently as larger notches in the caudal part of the ventral edge and at the rear edge. At times, however, there also occurs a more abundant series of indentations which is always somewhat coarser on the blunted dorsal edge than on the sharp ventral edge where it reaches to the ventral furrow.

APOGONIDAE

OTOLITHUS (APOGONIDARUM) HOSPES Koken

Plate 29, fig. 15

Length, 3.5 mm.; breadth, 3 mm.; thickness, 0.7 mm.

Shape.—Roundish; inner and out side convex to about the same degree; the exterior is divided by a semi-circular depression issuing from the deep excisura ostii into a smaller dorsal; and larger and thickened ventral half. About the middle the dorsal half again is occupied by a depression going to the edge. The sculpture consists

[1] The figures on Plates I—III are more or less magnified and the measurements here given refer, unless otherwise indicated, to the specimens depicted.

more of elongated, radially placed and somewhat irregular protuberances than of real ribs.

In the inner side there occur regular radially placed ribs above the sulcus acusticus in the area. Parallel to the ventral edge there is a furrow below which the edge appears very delicately and regularly notched.

The sulcus acusticus is formed almost exactly as in *Otolithus (Apogonidarum) subrotundus* and hardly needs further description. The excisura ostii is very deep.

SPARIDAE

OTOLITHUS (PAGELLI) ELEGANTULUS Koken

Plate 28, figs. 5, 6

Length, 3.5 mm.; breadth, 2.5 mm.; thickness, 0.8 mm.

Shape.—Elliptical, in front pointed, but the projecting rostrum rounded behind, the edges not sharp.

The sculpture of the outer side is as follows: The ventral half forms an elevation, extending from the front to the back; the dorsal half is flat and traversed by a few broad, radially placed ribs which in their turn are cut by concentrical strips of growth. At the dorsal edge the ribs produce a blunt crenulation; the ventral edge is unserrated.

The relatively broad sulcus acusticus is divided into a distinctly set-off ostium and a cauda twice as long, which is rather sharply bent down in the rear. The excisura ostii is small but distinct; likewise the dorsal edge of the antirostrum. The division of the ostium

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EXPLANTION OF PLATE 28

FIGS. 1–3.—*Otolithus (Carangidarum) americanus* Koken. Figs. 1 and 2, inside; fig. 3, outside.

4.—*Cepola rubescens.* Inside.

5–6.—*Otolithus (Pagelli) elegantulus* Koken. Fig. 5, inside; fig. 6, outside.

7.—*Mugil saliens.* Inside.

8.—*Otolithus (Mugilidarum) debilis* Koken. Inside.

9.—*Otolithus (Sparidarum) insuetus* Koken. Inside.

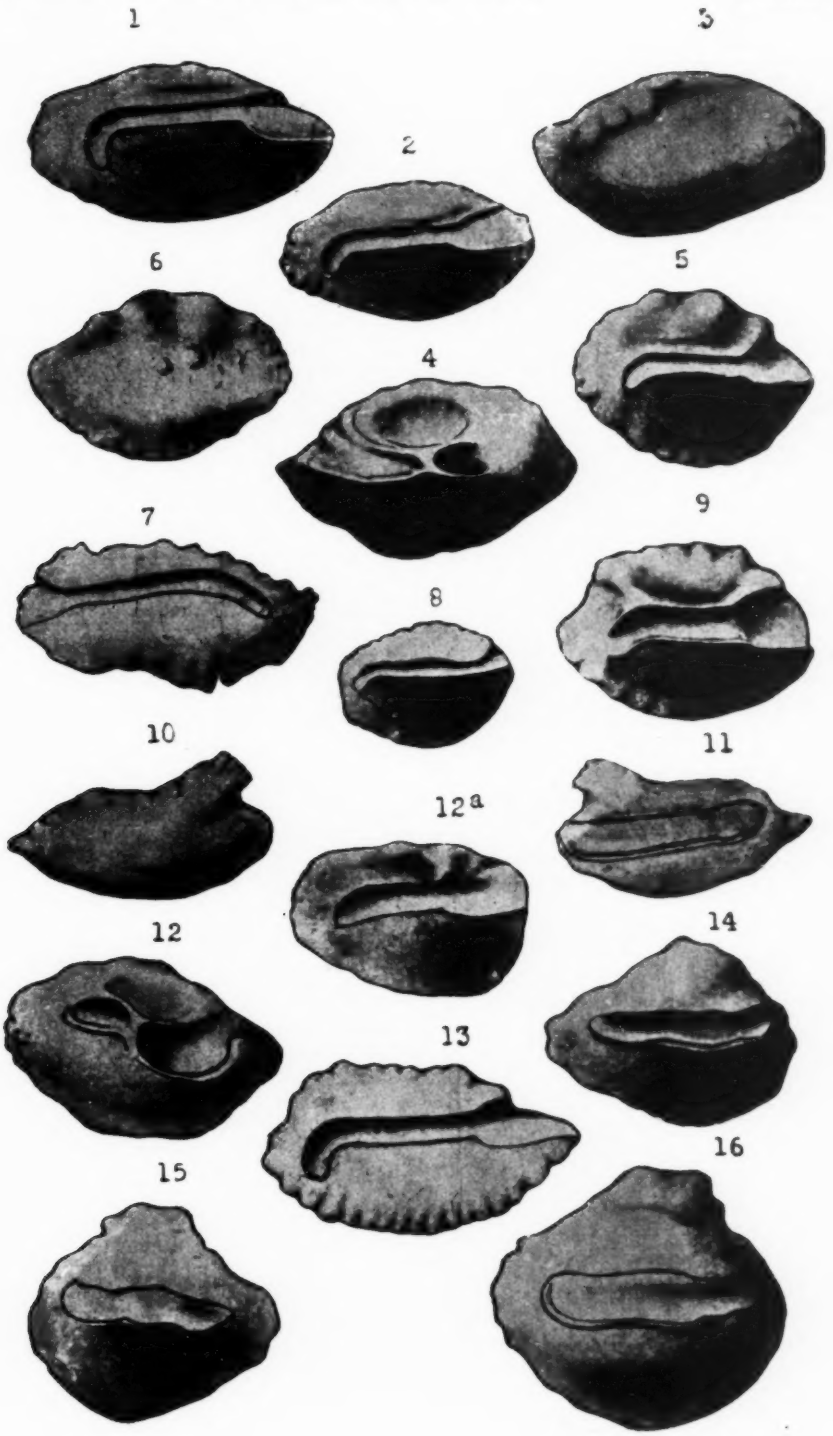
10–11.—*Otolithus (Gadidarum) mucronatus* Koken. Fig. 10, outside; fig. 11, inside.

12.—*Otolithus (Cepolae) comes* Koken. Inside.

12a.—*Otolithus* (inc. sedis) aff. *umbonata* Koken. Inside.

13.—*Caranx trachurus.* Inside.

14–16.—*Otolithus (Platessae) sector* Koken. Inside.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from the cauda is affected by the dorsal edge of the sulcus turning up and the ventral down; also, it is sunk more deeply than the cauda. A delicate ridge with accompanying depression originates at the end of the cauda, running parallel to the ventral edge, below which the edge appears somewhat wavy. Dorsally, the sulcus acusticus is accompanied by a crista superior, above which lies a narrow but rather deep area. From the blunt teeth of the dorsal edge, irregular furrows extend also to the inner side.

The form and sculpture of this otolith agrees so extremely well with the otoliths of *Pagellus* that I associate it with this genus without hesitation.[2]

Otolithus (Sparidarum) Sollignensis[3] is distinguished by a relatively large ostium, the lack of an excisura, the wavy curve of the cauda, and the manner in which the outer side is sunk.

Occurrence.—A specimen from Jackson River.

OTOLITHUS (SPARIDARUM) INSUETUS Koken
Plate 28, fig. 9

Length, 3.8 mm.; breadth, 2.6 mm.

Shape.—Externally this otolith is rather similar to the preceding one, but rather easily distinguished by the much broader cauda of the sulcus acusticus and the dorsal limitation of the ostium which is curved upward only a little and thereby becomes a more regular oblong. The crista superior and the area lying above it are distinctly developed. The sculpture shows nothing particularly remarkable.

SCIAENIDAE

OTOLITHUS (SCIAENIDARUM) RADIANS Koken
Plate 30, figs. 7, 8

Length, 3.5 mm.; breadth, 3.1 mm.; thickness, 0.6 mm.

Shape.—Flat, roundish. The dorsal edge merges in a strong curve with the straight front edge. The ventral edge is cut off short, almost perpendicularly; the dorsal edge curved slightly.

The outer edge is very slightly sunk, wavy in the middle and at the edge set with distinct tubercles. The ventral edge of the inner side is serrated very delicately and gracefully by radial ribs which are short and sharp and reach to the somewhat distinct ventral furrow. The dorsal edge is somewhat distorted by the tubercles of

[2] Zeitschrift. 1884, t. X f., 9.
[3] l., c., t., XII f., 11.

the outer edge which form a transition to the inner edge, and is irregularly toothed.

The sulcus shows the well-known form of the Sciaenidae and does not need further description. The cauda is more strongly sunk than the ostium, sharply bent and extends deeper than the ventral limitation of the ostium. In the decoration of the ventral edge of the inner side and the shallow dish-like depression of the outer side, as well as the shape of the ostium, there seems to be a strong agreement with the otoliths of *Corvina nigra* which nevertheless are distinguishable by the sculpture which is particularly rich on the outer side. *Otolithus gibberulus* from the upper Oligocene of Cassel, etc., is also related but there is lacking the radial rib of the ventral edge of the inner side.

Occurrence.—Vicksburg; one specimen.

OTOLITHUS (SCIAENIDARUM) GEMMA Koken
Plate 30, figs. 9, 13

Length, 10 mm.; breadth, 9.5 mm.; thickness, 3 mm.

Shape.—Round: front and back edge mostly form an almost continuous, almost circular curve, while the dorsal edge is a straight line, and only once in a while has a shallow, blunt-edge notch whose vertex lies above the boundary of ostium and cauda. The inner side is uniformly convex; the outer side diagonally concave, in some cases parted by a curve, convexly arched in front, and situated on the rear half, into two thickened portions with a shallow valley lying between. These two thickened portions occasionally also merge, whereby the valley in between is obliterated and preserved only at the sides vestigially, especially the dorsal side. The edges of the outer side forming a very sharp angle with the inner side are concentrically striped in well preserved specimens. For the rest, the sculpture consists of wavy, seemingly irregular, bosses and depressions, but in one younger specimen there was observed somewhat more regular tubercles.

The inner side is as in *Umbriana*. *Otolithus gemma* is closely related to *O. (Sciaenidarum) irregularis* Koken; from the Upper Oligocene of Germany (Cassel, Detmold, etc.) and is differentiated from them especially by the generally shorter and more rounded shape and the less sharp division of the outer side into a frontal and rear eminence. Both, however, certainly belong to one genus, closely related to the living *Umbriana* and probably identical with it.

Occurrence.—Vicksburg; Red Bluff; Jackson River, Mississippi.

OTOLITHUS (SCIAENIDARUM) EPORRECTUS Koken

Plate 29, figs. 16, 17

Length, 8.25 mm.; breadth, 5.25 mm.; thickness, 1.5 mm.

Shape.—Elongated elliptical with the frontal and ventral edge showing a continual curve, whereas the rear edge and the dorsal edge are more straight-lined and set off more sharply from one another. Also, inside of the dorsal edge there occurs above the boundary, between the ostium and cauda, a wide-angled notch. The inner side is convex; the outer side diagonally concave and provided with several coarse wrinkles perpendicular to the longitudinal axis.

The sulcus acusticus is characterized by a very long drawn out but still spatula-shaped ostium not generally seen in the Hilluidae, and by a cauda which is bent downward only slightly and very gradually and in which there are some collicular formations. The area above the sulcus is moderately deepened.

Occurrence.—Newton, Mississippi; one specimen.

OTOLITHUS (SCIAENIDARUM) CLAIBORNENSIS Koken

Plate 30, figs. 1, 4

Largest specimen: Length, 8 mm.; breadth, 6 mm.; thickness, 2 mm.

Shape.—The dorsal edge is bluntly notched in the middle and joins the rear edge almost at a right angle. The ventral edge is rounded and clearly set off from the rear edge and the frontal edge. The inner side is strongly convex, the outer side diagonally concave. The profile, therefore, shows a strong curvature. The sculpture consists for the most part only of wrinkles, traversing the outer side, of which especially the nearest to the rear edge is strongly curved, with its convexity in front. Younger and better preserved specimens show that these wrinkles compound to ribs which originate from the median line and are thickened here and there into tubercles, between which there are additionally found at the edges some few elongated tubercles.

The ostium closely resembles in its formation the preceding species *(O. eporrectus)* while the cauda is sharply bent downward as in *O. gemma* and *O. radians.*

Occurrence.—Claiborne, Alabama; very frequent.

OTOLITHUS (SCIAENIDARUM) INTERMEDIUS Koken
Plate 30, figs. 2, 3

Largest specimen: Length, 8.3 mm.; breadth, 7 mm.; thickness, 1.7 mm.

In shape very similar to the preceding one, but generally shorter relatively. The outer side is wrinkled across as in *O. claibornensis*, but the number of these wavy protuberances is larger, and dichotomizing occurs, especially toward the ventral edge. The sulcus again is rather similar to that of *O. gemma*, the ostium being considerably broader and relatively shorter than in the two species just described, without attaining the extent described in that species. Above the sulcus there lies an elongated area in which weakly developed radial ribs are visible. Below the ventral furrow, seen mostly only as a dark line, there stand likewise fine and closely appressed riblets, such as occur in *O. radians*. This otolith is most nearly related to the latter.

Occurrence.—Claiborne, Alabama; not frequent.

OTOLITHUS (SCIAENIDARUM) SIMILIS Koken
Plate 30, figs. 10, 11, 14

Length, 4.8 mm.; breadth, 3.5 mm.; thickness, 1.4 mm.

Length, 4 mm.; breadth, 2.3 mm.; thickness, 0.5 mm.

Shape.—Very similar to *O. claibornensis* but generally smaller, more equally curved (without the sharp edge between the dorsal and the rear edge), and especially distinguished by the abundant and different sculpture of the outer side. For the most part, the middle of the outer side is distinctly raised and surrounded by a flat depression within which there are only faintly perceptible ribs. On the other hand the edge is set with thick tuberculous ribs which are divided by short, deep furrows and occasionally are bifurcated at the outside. The small specimens show this sculpture quite distinctly, whereas in older ones it is less conspicuous, and frequently reduced to wavy unevenness of the edge. Also, the median ridge of the outer side occasionally disappears, or assumes a more elongated form. I have never observed specimens which show the diagonal wrinkles of *O. claibornensis*. The sulcus does not show any particular differences; the part of the cauda turned down is somewhat shorter; and excisura ostii, to which corresponds on the outside an especially deep forrow, can mostly be recognized. The inner side is delicately furrowed radially in the ventral half in the case of the smaller specimens.

Occurrence.—Jackson, Mississippi.

OTOLITHUS (SCIAENIDARUM) DECIPIENS Koken
Plate 30, figs. 5, 6

Length, 6.9 mm.; breadth, 4.5 mm.; thickness, 2 mm.
Length, 7 mm.; breadth, 4.5 mm.; thickness, 1.7 mm.

Comparatively large otoliths, shaped like a rather elongated ellipse of which one side (the frontal one) closes with an acute angle while the other one is rounded. The inner side is strongly convex and almost evenly arched. Near the upper edge one observes a strong curved depression which is rounded in front, and in the rear closely joins the edge and merges in it. Only rarely may one observe a more definite form of the rear end of this depression. This is the cauda of the sulcus acusticus. In the case of very well-preserved specimens an equally depressed line may be seen on the inner side which in general corresponds to the outlines of the otolith and surrounds a very large area—the ostium of the sulcus acusticus. In the case of the Sciaenides this is, to be sure, very large and slightly depressed, and in the case of *Corvina ronchus*, for example, whose otoliths are shown on Plate 30, fig. 12, for the sake of comparison, one finds conditions quite analogous to that of *Otolithus decipiens*. The cauda of the sulcus forms a very strong depression, merging into the edge. One must consider the whole remaining, strongly convex, inner side as the ostium. In the preparation of these otoliths one observes that the unusually large membrana tectoria of the whole inner side clings firmly to the otolith and also that the macula

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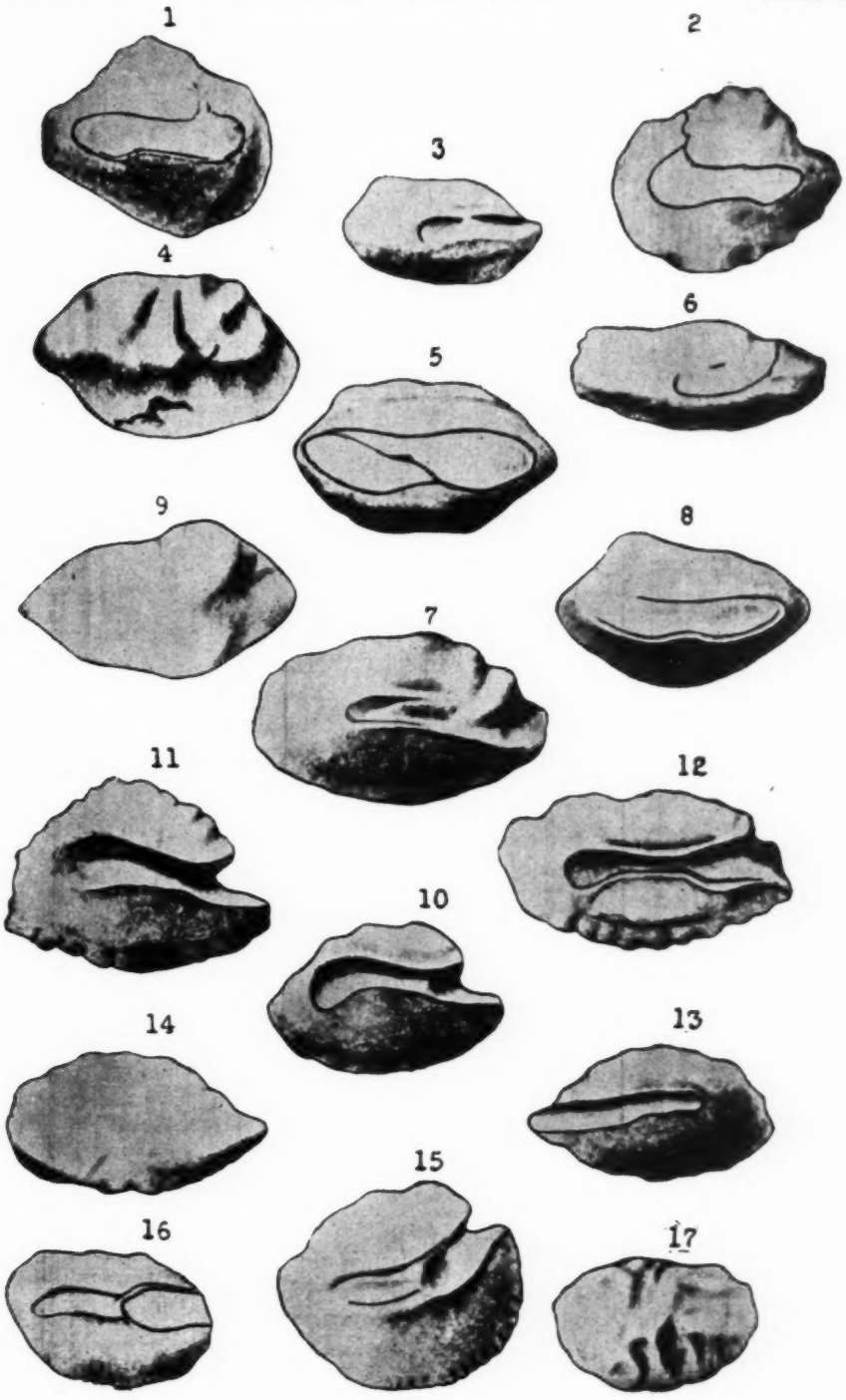
EXPLANATION OF PLATE 29

FIGS. 1–2.—*Platessa flesus*. Inside.
3.—*Otolithus (Soleae) glaber* Koken. Inside.
4–5.—*Otolithus (Gadidarum) elevatus* Koken. Fig. 4, outside; fig. 5, inside.
6.—*Conger myrus*. Inside.
7.—*Otolithus (Congeris) brevior* Koken. Inside.
8–9.—*Otolithus (Gadidarum) meyeri* Koken. Fig. 8, inside; fig. 9, outside.
10.—*Otolithus (Triglae) cor* Koken. Inside.
11.—*Trigla lineata* L. Inside.
12.—*Otolithus (Cottidarum) sulcatus* Koken. Inside.
13–14.—*Otolithus (Trachini) laevigatus* Koken. Fig. 13, inside; fig. 14, outside.
15.—*Otolithus (Apogonidarum) hospes* Koken. Inside.
16–17.—*Otolithus (Sciaenidarum) eporrectus* Koken. Fig. 16, inside; fig. 17, outside.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acustica which is the epithelial massing on the inner wall of the sacculus in which the nerve fibers end, is correspondingly shaped. For that matter, the peculiar dull lustre of the inner side of such otoliths would make one suppose that it was clothed by a firmer membrane, whereas the firmly developed outer edge presents itself differently to the eye, even apart from the marked sculpture.

The sculpture of the outer side is irregular just as in *Otolithus decipiens*. Just as in many Sciaenidae, two elevations formed by the thickening of the front and rear side bound a medial depression. By the formation of furrows and elevations, the latter at times in the form of projecting tubercles, a further differentiation occurs which cannot, however, be definitely indicated.

Occurrence.—Otolithus decipiens belongs to the more frequent finds in the Claiborne deposits.

TRACHINIDAE

OTOLITHUS (TRACHINI) LAEVIGATUS Koken

Plate 29, figs. 13, 14

Length, 3.5 mm.; breadth, 2.1 mm.

Length, 2.5 mm.; breadth, 1.5 mm.

Shape.—Elongated, pointed in front; the dorsal edge is more strongly curved than the ventral edge. The inner side is convex; the outer side distinctly concave. The rostrum projects strongly and is marked off also on the outer side as a thickening which joins the ventral edge and is accompanied dorsally by a furrow. This elevation runs to the middle of the otolith (umbo) and joins there a thickening which originates at the rear edges of the otolith and joins the ventral edge. On this side a low-lying dorsal field of the outer edge is divided off which is traversed by some few flat ribs radiating from the umbo.

Occurrence.—Otolithus (Trachini) laevigatus is fairly frequent in the Jackson beds.

COTTIDAE

OTOLITHUS (COTTIDARUM) SULCATUS Koken

Plate 29, fig. 12

Length, 3.4 mm.; breadth, 1.7 mm.; thickness, 0.5 mm.

Shape.—Of longish shape with diagonally concave outer side and inner side. The sculpture of the latter consists, apart from the sul-

convex inner side. The sculpture of the latter consists, apart from the sulcus acusticus, of delicate, rather regular furrows of the ventral

edge, which may be followed to the distinct ventral furrow, and of irregular more distinctly expressed embayments of the dorsal and rear edge. The frontal edge is notched by an excisura ostii; the rostrum (not entirely preserved) is very large, and also the antirostrum is distinctly developed.

The sulcus is narrowed in the middle; ostium and cauda are almost equally large each one depressed, and the latter somewhat bent downward. The sulcus is divided off from the distinctly expressed area by a sharp ridge.

The outer side is only slightly concave, longitudinally; a longitudinal ridge originates on the rostrum and extends to the rear edge where it is lost in an irregular, dorsally spread swelling. A deep furrow corresponding to the excisura ostii of the inner side leads to the middle of this longitudinal raise, which is marked by a small tubercle. From the ventral edge, fairly regular ribs extend toward the longitudinal ridge, in the frontal half perpendicular to the longitudinal axis, further in the rear converging on the central tubercle. The ribs of the dorsal edge are less numerous, coarser, and irregular.

This otolith does not seem to belong to *Trigla*, but the sulcus acusticus is that of a cataphract fish. The elongated shape resembles *Cottus*.

Occurrence.—One specimen from Jackson River.

OTOLITHUS (TRIGLAE) COR Koken
Plate 29, fig. 10

Length, 2.6 mm.; breadth, 1.7 mm.; thickness, about 0.4 mm.

Shape.—Somewhat three-cornered, elongated, heart-shaped. The frontal edge has a deep embayment made by the broad excisura ostii. The dorsal edge unites directly with the ventral edge in an acute angle. Both are bent with a shallow curvature. The sulcus acusticus is broad, deep, and bent slightly "S"-shape. The depressed ostium which is embayed by a broad excisura is divided from the cauda by a narrowing of the sulcus. The cauda is widened in its rear part, deepened and bent downwards. The crista superior is distinctly developed. Above it there lies an elongated area. The edges are notched in a blunt fashion; the outer side is concave and smooth.

This otolith in its shape resembles most closely that of *Trigla lineata* from the Mediterranean Sea, as Plate 29, fig. 11 shows. The *O. (Triglae) ellipticus* from the German middle Oligocene, described by me corresponds more closely to the roundish or rhombic otoliths of *Trigla corax* and *T. aspera*.

Occurrence.—One specimen from the Jackson River.

CEPOLIDAE

OTOLITHUS (CEPOLAE) COMES Koken

Plate 28, fig. 12

Length, 4.5 mm.; breadth, 3 mm.; thickness, 0.7 mm.

Shape.—Flat. Ventral edge equally round; dorsal edge more of an angle, the vertex of which is placed somewhat backward beyond the middle. Inner side, weakly convex; outer side, generally flat with arched middle concentric depression following thereupon, and irregular tubercles along the edge which, however, allow one to recognize radial disposition.

Sulcus bent with small cauda, large ostium axe-shaped.

Ostium and cauda depressed and divided by a diagonal ridge, the ostium separated from the front edge but united with the dorsal edge in a broad opening. The edges of the sulcus have a beading. Dorsally, there is found a definitely area; ventrally, a distinct depression parallel to the ventral edge.

The association of this otolith with the living genus *Cepola* is clear from the picture of the sagitta of *Cepola rubescens*, Plate 28, fig. 4.

Occurrence.—Jackson River, Mississippi; one specimen.

MUGILIDAE

OTOLITHUS (MUGILIDARUM) DEBILIS Koken

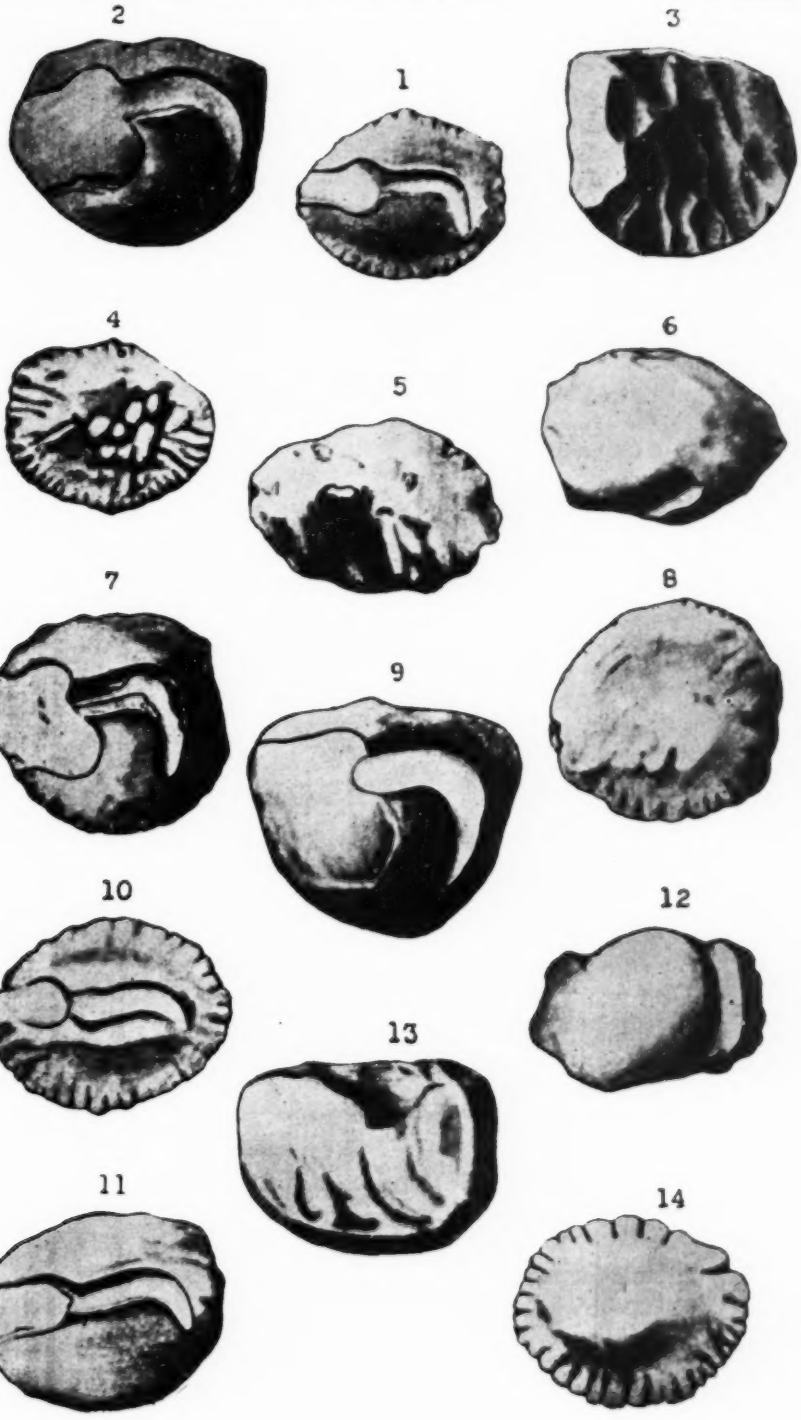
Plate 28, fig. 8

Length, 2.5 mm.; breadth, 1.9 mm.; thickness, 0.3 mm.

Shape.—Elongated elliptical, dorsal edge only slightly curved.

EXPLANATION OF PLATE 30

FIG. 1.—*Otolithus (Sciaenidarum) claibornenesis* Koken. Inside.
2–3.—*Otolithus (Sciaenidarum) intermedius* Koken. Fig. 2, inside; fig. 3, outside.
4.—*Otolithus (Sciaenidarum) claibornensis* Koken. Outside.
5–6.—*Otolithus (Sciaenidarum) decipiens* Koken. Fig. 5, outside; fig. 6, inside.
7–8.—*Otolithus (Sciaenidarum) radians* Koken. Fig. 7, inside; fig. 8, outside.
9.—*Otolithus (Sciaenidarum) gemma* Koken. Inside.
10.—*Otolithus (Sciaenidarum) similis* Koken. Inside.
11.—*Otolithus (Sciaenidarum) similis* Koken. Inside.
12.—*Corvina ronchus* L. Inside.
13.—*Otolithus (Sciaenidarum) gemma* Koken. Outside.
14.—*Otolithus (Sciaenidarum) similis* Koken. Outside.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Ventral edge strongly and equally bent. The sulcus acusticus approaches the dorsal edge and is divided into a long, narrow cauda and a very small ostium. Only the end of the cauda is bent abruptly down in the shape of a hook. The dorsal limitation of the ostium is bent rather strongly upward, the ventral edge lies almost in the prolongation of that of the cauda. An excisura is lacking, but there exists a faintly expressed ostial furrow in its place. A ventral furrow parallels the ventral edge from the end of the cauda to the ostium. Above the "crista superior" there lies a faintly expressed elongated area out of which short ribs and furrows lead to the dorsal edge. The outer side is equally concave and possesses only indistinct ribs or protuberances along the edge. The sulcus is shaped just as in *Mugil*. However, the form of the otoliths in the genus is more elongated, the sculpture more distinct, almost coarse. Compare Plate 28, fig. 7. *Atherina* is fairly similar as to shape, but differs especially by the entirely straight and elongated cauda.

Occurrence.—Four specimens from Jackson River.

ANACANTHINI

GADIDAE

OTOLITHUS (GADIDARUM) MEYERI Koken

Plate 29, figs. 8, 9

Length, 4 mm.; breadth, 2.2 mm.; thickness, 1.2 mm.

Shape.—Elliptical, angular in the rear, shaped almost like an apple-seed. The inner side is equably arched, lustrous; the outer side also arched, thickened, especially in front and above and set with single or clustered, relatively large, roundish tubercles. Only the bent-up, sharp rear edge and the curvature of the edges allows one, as in most otoliths, to recognize the diagonal, concave structure of the outer side.

The ventral edge is very sharp, whereas dorsally the outer edge diverges from the inner side always at an angle.

The sulcus is very slightly, depressed, closed in front, and behind broad and divided by a projection of the ventral edge into two almost equally large parts which correspond to the ostium and the cauda. A furrow which is drawn diagonally from above in front to below behind marks also a division of the colliculars formations filling it. The ventral furrow is to be recognized only with difficulty. In front, the sulcus is divided only slightly from the frontal edge. An occasional distinctly marked slanting end, slight indentations of the same,

allow one to recognize that this portion corresponds to the rostrum and antirostrum of other otoliths.

Occurrence.—Several specimens from Jackson River.

OTOLITHUS (GADIDARUM) ELEVATUS Koken
Plate 29, figs. 4, 5

Length, 3.8 mm.; thickness, 1.4 mm.; breadth, 2.5 mm.

Closely related to the above, but differing in its shape, by greater breadth, and thickness, and stronger rounding of the inner side. The sulcus is still broader, and the strip of the inner side lying over it dorsally is thereby narrowed considerably. A ventral furrow is hardly to be recognized any longer. The infrequent, but strongly pronounced tubercles of the outer side lie almost completely in the dorsal half.

OTOLITHUS (GADIDARUM) MUCRONATUS Koken
Plate 28, figs. 10, 11

Length, 6 mm.; breadth, 3.2 mm.; thickness, 1 mm.

Shape.—Elongated, rounded in front, acute behind. The dorsal edge has an additional growth pointing upward diagonally. The inner side is arched, the outer side distinctly diagonally concave. The ventral edge is sharper than the dorsal edge.

The sulcus is flat, filled with weak collicula and forms a band of equable breadth, bounded by parallel and straight ventral and dorsal edges. This band is divided from the rear edge of the otolith by a rather large interval, but still communicates with the front edge by a very weakly expressed furrow. The collicula is by far the larger. Above the sulcus there lies, divided by a crista from it, a distinct area which extends to the frontal edge; below the sulcus, closely oppressed to the frontal edge, a weak ventral furrow is to be observed. The outer side is irregularly gibbose, wavy and adorned by a row of distinctly formed tubercles, in the portion close to the dorsal edge.

Of *Otolithus mucronatus*, only one specimen is known to me, from Claiborne.

PLEURONECTIDAE

OTOLITHUS (PLATESSAE) SECTOR Koken
Plate 28, figs. 14, 16

Length, 7.0 mm.; breadth, 5.5 mm.; thickness, 2.0 mm.
Length, 6.7 mm.; breadth, 5.2 mm.; thickness, 1.5 mm.

Shape.—Flat, like the segment of a circle, the ventral edge being almost equally rounded, whereas the dorsal edge is broken off in an acute angle so that the line bisecting this angle would divide the otolith into almost equal portions. In youth also the ventral edge is acute, the shape therefore more rhomboid.

The sulcus is relatively broad, narrow behind, so as to come to a sharp end, and divided only by a slight projection of the ventral seam into a small cauda and a large ostium. The connection with the frontal edge is almost obliterated; on the other hand a furrow beginning a slight distance behind the front edge of the sulcus and directed rather to the rear goes to the dorsal edge of the otolith, or at any rate to a depression which is below the acute dorsal edge.

The inner side is equably convex, with the exception of the just mentioned depression and the sulcus, the outer side either irregularly concave, or either by a thickening of the dorsal edge, or else almost irregularly convex through a thickening in the region of the ventral edge. Only rarely among our specimens this ventral dwelling is differentiated somewhat more by furrows going to the edge.

The similarity with the otoliths of the Platessae, especially of *Platessa flesus*, of which species there are furnished pictures for comparison (Plate 29, figs. 1, 2) is indeed surprising. The short cauda of the sulcus, the long ostium divided from the frontal edge, the connection with the dorsal edge, or a depression accompanying the latter; in fact, the whole form of the otolith and the slight sculpturing are found in both and exclude any doubt as to their close relationship.

In America, *Otolithus (P'atessae) sector* of the Claiborne to the Vicksburg deposits is one of the most frequent otoliths, especially frequent in the Jackson strata and everywhere distinguished by the same characteristics.

OTOLITHUS (SOLEAE) GLABER Koken

Plate 29, fig. 3

Length, 3 mm.; breadth, 1.6 mm.; thickness, 0.9 mm.

Rear side cut off round, very slightly sinuate, front side acute, inner side flat, outer side arched smooth.

Sulcus directed diagonally downward from behind, divided from the frontal edge by a very narrow seam. It is divided by a very slight restriction into ostium and cauda, each of which is somewhat depressed. The ostium narrows in front somewhat. A connected colliculum goes from the cauda into the ostium, where it suddenly narrows and ends in a point. Dorsally, there is an area over the

sulcus. On the outer side, a furrow indicates the position of the rostrum, or else of the excisura ostii.

Occurrence.—One specimen from the Jackson deposits.

PHYSOSTOMI

MURAENIDAE

OTOLITHUS (CONGERIS) BREVIOR Koken

Plate 29, fig. 7

Length, 3.2 mm.; breadth, 2 mm.; thickness, 1 mm.

Shape.—Elongated acute in front. Edges blunt. Especially distinctive is the broad, short sulcus whose ventral boundary runs in a straight line to the pointed rostrum, whereas the dorsal boundary—distinguished only for a short distance as crista superior—bends upward somewhat in front whereby arises a broadening, which is to be interpreted as the ostium. Between rostrum and antirostrum, there lies a third projection bounded above and below by furrows which disappear in the ostium. The whole sulcus is gibbose and not defined sharply. Above the short crista superior there lies an equally short area. The dorsal edge is unevenly notched, only in front two crenulations are more distinct. The outer side offers nothing worthy of remark. It is diagonally concave, traversed by a longitudinal ridge which originates in the rostrum and gradually becomes weaker toward the rear. Toward the edges there occur indistinct ribs and furrows.

It is especially the form of the sulcus acusticus which points to relationship with *Conger,* as the otolith of *Conger myrus* pictured, Plate 29, fig. 6, will allow one to recognize.

Occurrence.—Both otoliths, the only specimens so far found, are from the Jackson beds.

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NEW MIOCENE MOLLUSKS FROM CALIFORNIA

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During further study of Miocene invertebrate marine faunas of California, several new species were distinguished, most of which were collected from the Vaqueros formation of the lower Miocene. Others were obtained from the Temblor and Monterey formations of later Miocene. Similar individuals have been previously collected but never described.

The writer[1] recently reviewed the Vaqueros and Temblor formations and described a number of new species. Considering it expedient to record the additional new material, the present brief notes were prepared.

ANOMIA HANNAI Wiedey, n. sp.
Plate 31, fig. 1

Shell quite large, not thick, subovoid, rather convex near beak, flattened toward basal margin, more pointed and angular in umbonal area; surface sculptured by about ten coarse, low, irregularly radiating ribs, which tend to split; interior surface irregular, deep in vicinity of beak; ligamental pit apparently broad, deep, but not high. Height, 67 mm.; breadth, 57 mm.; thickness, single valve, 18 mm.

Holotype.—L. S. J. U.[2] type collection, type No. 514, from L. S. J. U. Loc. 449. Collected from Val Celico, a little west of Pleyto, Monterey County, California. Wayne Loel, collector; Vaqueros formation, lower Miocene.

[1] Wiedey, Lionel William, "Notes on the Vaqueros and Temblor Formations of the California Miocene with Descriptions of New Species", Trans. San Diego Soc. Nat. Hist., vol. 5, no. 10, 1928, pp. 95-182; pls. 9-21.
[2] Leland Stanford Junior University.

The fewer ribs and larger form serve to distinguish this new species from *Anomia peruviana* d'Orbigny, living in the Gulf of California. *A. hannai* is more triangular and less gibbose than the average form of *A. subcostata* Conrad[3] of the Carrizo Creek beds, lower Pliocene in age, of Imperial County, California.

This new species is named for Dr. G. Dallas Hanna in recognition of his many valuable contributions to the knowledge of the paleontology of the Pacific Coast.

MYTILUS KEWI Wiedey, n. sp.
Plate 31, fig. 2

Shell of large size, highly inflated, with a prominent high, rounded elevation passing from beak to posterior extremity of shell; posterior margin long, evenly rounded, sharply so near beak with tendency toward straightening near extremity; beak low and sharply projected forward; entire shell of scimiter-shaped appearance; external surface sculptured only by inconspicuous lines of growth; interior unknown; in combined valves anterior dorsal portions form a broad flat area which merges into elevated portion, which is nearly vertically above suture. Height, 102 mm.; breadth, 53 mm.; thickness, single valve, 22 mm.

Holotype.—L. S. J. U. type collection, type No. 515, from L. S. J. U. Loc. 200. Collected at the type section of the Vaqueros formation, Los Vaqueros Valley, Monterey County, California. Vaqueros formation, lower Miocene.

The sharp and pointed beaks, together with the generally highly arcuate shape distinguish *M. kewi* from *M. mathewsonii* Gabb[4] and *M. mathewsonii* var. *expansus* Arnold,[5] *M. coalingensis* Arnold[6] is less arcuate than this new species.

Named in honor of Dr. W. S. W. Kew, who has contributed greatly to the knowledge to the stratigraphy of California.

DOSINIA MORANI Wiedey, n. sp.
Plate 31, fig. 3; plate 32, fig. 3

Shell large, slightly inequilateral, somewhat highly subcircular, a little higher than wide; shell margins evenly rounded except at anterior extremity, that portion being a little more sharply rounded; form very gibbose, inflation evenly developed to basal margin; umbones not prominent, beaks inconspicuous, turned forward; lunule

[3] Hanna, G. Dallas, Proc. Calif. Acad. Sci., 4th ser., vol. 14, no. 18, 1926, pl. 23, figs. 3, 4, 5.
[4] Gabb, W. M., Pal. of Calif., vol. 2, 1866, pl. 8, fig. 51.
[5] Arnold, Ralph, Proc. U. S. Nat. Mus., vol. 32, 1907, pl. 43, fig. 2.
[6] Arnold, Ralph, U. S. Geol. Surv. Bull., no. 398, 1910, pl. 41, fig. 5; pl. 44, fig. 6.

not large, nearly as broad as high; escutcheon short, very narrow and apparently very shallow; sculpture consisting entirely of closely spaced, low, rounded, concentric ridgelets. Height, 73 mm.; breadth, 75 mm.; thickness, combined valves, 48 mm.

Holotype.—L. S. J. U. type collection, type No. 516, from L. S. J. U. locality 441. Collected from the head of Canyon de Piedra, about five miles east of San Luis Obispo, San Luis Obispo County, California. R. B. Moran, collector; Vaqueros formation, lower Miocene.

The somewhat greater height, regular sculpture, composed of prominent, numerous concentric ridges, and thicker form of this species serve to distinguish it from *Dosinia merriami* Clark.[7]

This new species is named for Mr. R. B. Moran in recognition of his extended efforts toward securing faunas from the lower Miocene in the San Luis Obispo region.

CHIONE VALENTINEI Wiedey, n. sp.
Plate 31, fig. 4; plate 32, fig. 1

Shell of moderate size, equivalve, very inequilateral, not greatly inflated; length approaching twice width; anterior margin short, dropping nearly vertically downward from beak to extremity; latter sharply rounded and often prominently projecting; basal margin very long and very broadly rounded; posterior extremity projected, sharply rounded; posterior very long and nearly straight; umbones

[7] Clark, Bruce L., Univ. of Calif. Publ., Bull. Dept. Geol., vol. 8, no. 22, 1915, pl. 52, fig. 1.

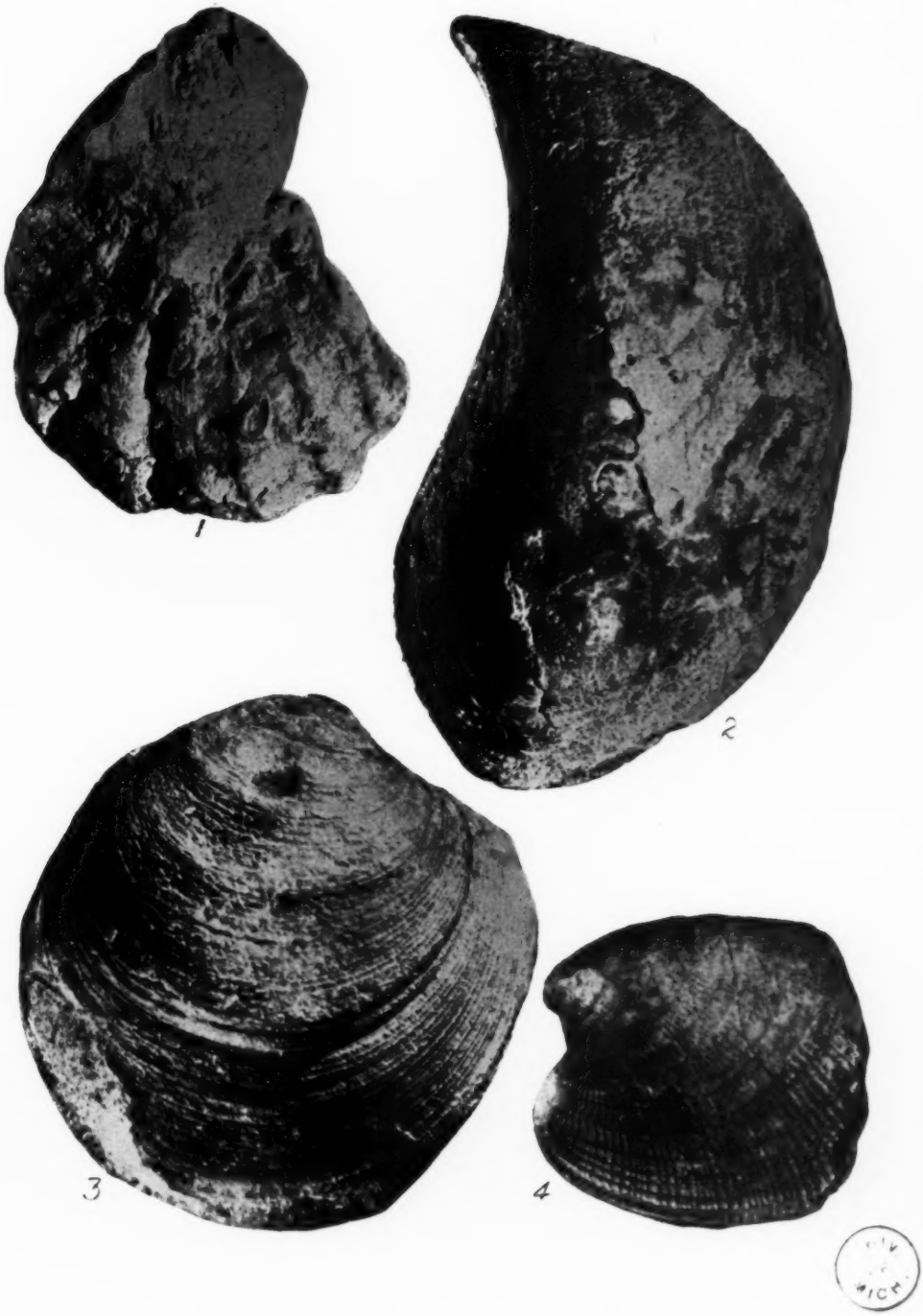
EXPLANATION OF PLATE 31

FIG. 1.—*Anomia hannai* Wiedey, n. sp.; height of specimen, 67 mm. Holotype, No. 514 (L. S. J. U. type collection), from L. S. J. U. Loc. 449, Val Celico, Monterey County, California. Vaqueros formation, lower Miocene.

2.—*Mytilus kewi* Wiedey, n. sp.; height of specimen, 102 mm. Holotype, No. 515 (L. S. J. U. type collection), from L. S. J. U. Loc. 200, Vaqueros type section, Los Vaqueros Valley, Monterey County, California. Lower Miocene.

3.—*Dosinia morani* Wiedey, n. sp.; height of specimen, 73 mm. Holotype, No. 516 (L. S. J. U. type collection), from L. S. J. U. Loc. 441, Canyon de Piedra, five miles east of San Luis Obispo, San Luis Obispo County, California Vaqueros formation, lower Miocene.

4.—*Chione valentinei* Wiedey, n. sp.; height of specimen, 43 mm. Holotype, No. 517 (L. S. J. U. type collection), from L. S. J. U. Loc. 448, two miles south of Mayfield, Santa Clara County, California. Temblor formation (?), middle Miocene.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prominently developed, sharp, greatly incurved and pointed downward; lunule very broadly cordate, deep and bounded by prominently impressed sutures; escutcheon long, narrow and quite deep; sculpture typical of genus, with numerous radiating ribs and well developed concentric ridges; hinge apparently composed of two prominent cardinals, posterior one widely bifidly divided; hinge line at angle of about 45° to long axis of shell. Height, 43 mm.; breadth, about 60 mm.; thickness, combined valves, 31 mm.

Holotype.—L. S. J. U. type collection, type No. 517, from L. S. J. U. Loc. 448. Collected from a soft Sandstone bed two miles south of Mayfield, Santa Clara County, California. The locality is in a small ravine trending south-southwest and stratigraphically appears to be several hundred feet lower in the Miocene than a Temblor horizon found nearby. However, this new species may not have come from the Temblor, but from the Purisima, found not distant. This seems possible in view of the faulting in the vicinity, but which in no way could be traced between the two above mentioned localities.

The shell of *C. valentinei* is more inequilateral, of lower height, apparently thinner, and more elongate than that of *Chione pabloensis* Clark.[8]

Named for Mr. W. W. Valentine in recognition of his greatly appreciated aid and encouragement in this work.

[8] Clark, Bruce L., Univ. of Calif. Publ., Bull. Dept. Geol., vol. 8, no. 22, 1915, pl. 58, fig. 2.

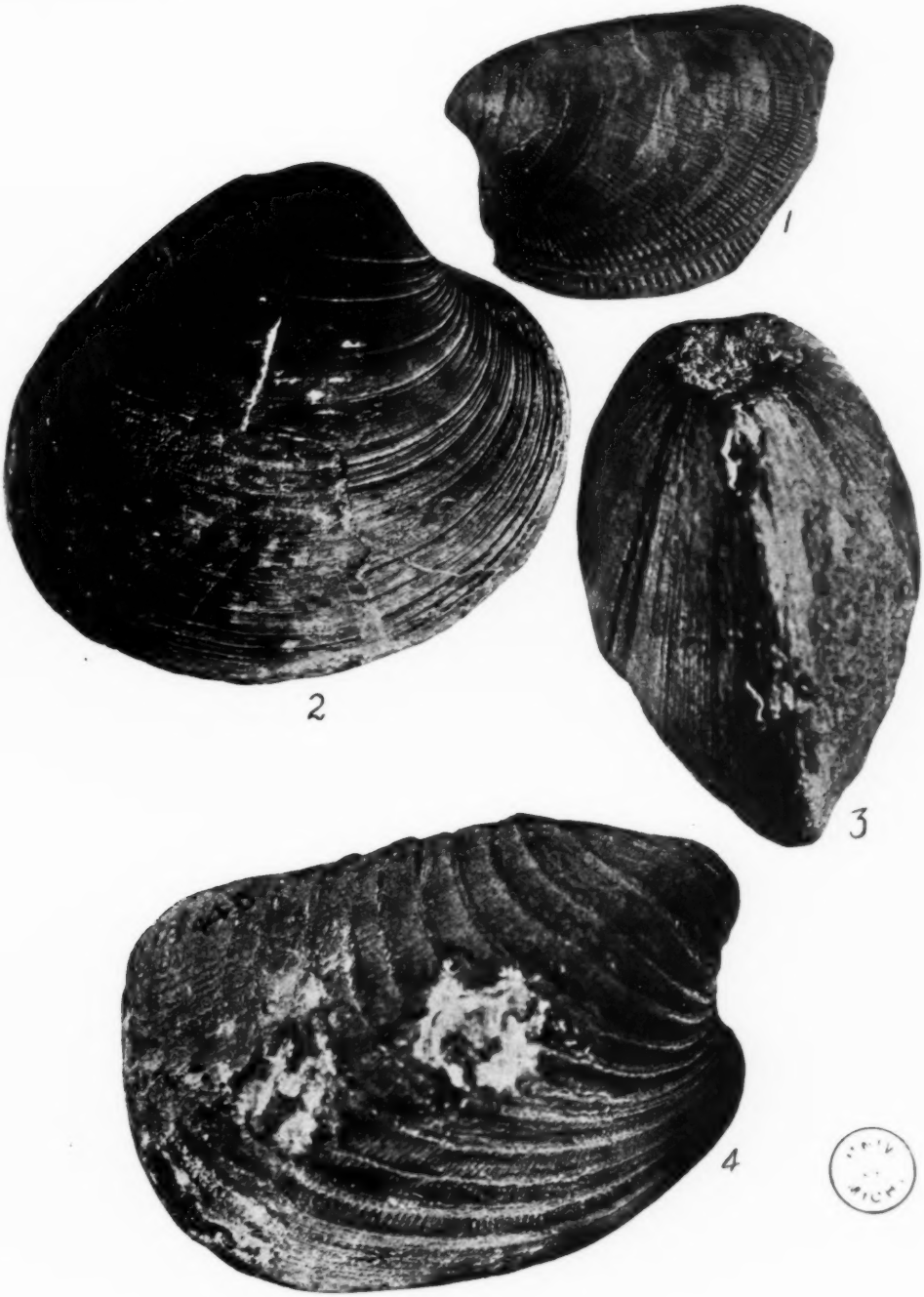
EXPLANATION OF PLATE 32

FIG. 1.—*Chione valentinei* Wiedey, n. sp.; height of specimen, 36 mm. Paratype, No. 53 (San Diego Soc. Nat. Hist. type collection), from L. S. J. U. and San Diego Soc. Nat. Hist. Loc. 448, two miles south of Mayfield, Santa Clara County, California. Temblor formation (?), middle Miocene.

2.—*Amiantis* (?) *loeli* Wiedey, n. sp.; height of specimen, 66 mm. Holotype, No. 519 (L. S. J. U. type collection), from L. S. J. U. Loc. 450, roadcut on Searsville Road, near Stanford University, San Mateo County, California. Monterey formation, middle Miocene.

3.—*Dosinia morani* Wiedey, n. sp.; height of specimen, 73 mm. Holotype, No. 516 (L. S. J. U. type collection). End view of specimen figure 3, plate 31.

4.—*Chione vickeryi* Wiedey, n. sp.; height of specimen, 61 mm. Holotype, No. 518 (L. S. J. U. type collection), from L. S. J. U. Loc. 451, 500 yards above the falls in Alum Rock Canyon, east of San Jose, Santa Clara County, California. Upper Monterey, middle Miocene.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CHIONE VICKERYI Wiedey, n. sp.
Plate 32, fig. 4

Shell very large, apparently equivalve, very inequilateral, massive; contour of anterior portion of valve from beak to basal margin sharply "S" shaped, with anterior extremity prominently projected forward; basal margin very long and gently rounded toward posterior extremity; latter feature truncated at nearly a right angle; posterior margin very long, nearly parallel to major portion of basal margin, nearly straight; width about three fifths of length; external shape also characterized by a prominent, highly arched, straight fold[9] of shell passing obliquely from beak to basal margin near posterior extremity; shell sculptured by about sixteen evenly spaced and prominent concentric ridges, and by numerous fine, radiating ridgelets; lunule obscured but small, deeply depressed; escutcheon long and narrow; interior of shell not accessible. Height, 61 mm.; breadth, 86 mm.; thickness, single valve, 36 mm.

Holotype.—L. S. J. U. type collection, type No. 518, from L. S. J. U. Loc. 451. Collected 500 yards upstream from the falls in Alum Rock Canyon, just east of San Jose, Santa Clara County, California. E. C. Templeton, collector; upper Monterey formation, middle Miocene.

This species has been collected from beds in the vicinity of others that have contained *Chione temblorensis* Anderson,[10] according to field reports. It is distinguished from Anderson's species, however, by the more elongate shell and absence of the prominently depressed area in the posterior portion of the shell.

This new species is named in honor of Dr. Frederick P. Vickery, whose inspiring suggestions have always been highly appreciated.

[9] This prominent ridge may have been accentuated by a slight crushing of the shell, but the former feature appears to be normal to several individuals and to have been an original shell character.

[10] Anderson, F. M., Proc. Calif. Acad. Sci., 3rd ser., vol. 2, no. 2, 1905, pl. 14, figs. 36, 37, 38.

EXPLANATION OF PLATE 33

FIG. 1.—*Tivela* (?) *vaquerosensis* Wiedey, n. sp.; height of specimen, 75 mm. Holotype, No. 520 (L. S. J. U. type collection), from L. S. J. U. Loc. 200, the type section of the Vaqueros formation, Los Vaqueros Valley, Monterey County, California. Lower Miocene.

2.—*Platyodon piedraensis* Wiedey, n. sp.; breadth of specimen, 63+(20?) mm. Holotype, No. 521 (L. S. J. U. type collection), from L. S. J. U. Loc. 441, Canyon de Piedra, five miles east of San Luis Obispo, San Luis Obispo County, California. Vaqueros formation, lower Miocene.

3.—*Amiantis* (?) *loeli* Wiedey, n. sp.; breadth of specimen, 75 mm. Top view of holotype, figure 2, plate 32.

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AMIANTIS (?) LOELI Wiedey, n. sp.
Plate 32, fig. 2; plate 33, fig. 3

Shell quite large, inequilateral, very gibbose, nearly as high as broad; anterior margin slightly more sharply rounded than basal margin; posterior extremity little more sharply rounded than anterior; posterior margin only gently curved, not long; umbones prominently elevated, evenly rounded; beaks very close set and strongly pointed forward; lunule cordate, of moderate size and not deep; escutcheon rather long, moderately wide; surface sculptured by more or less evenly spaced, low concentric ridges. Height, 86 mm.; breadth, 75 mm.; thickness, combined valves, 47 mm.

Holotype.—L. S. J. U. type collection, type No. 519, from L. S. J. U. Loc. 450. Collected from a roadcut on the Searsville Road, near Stanford University, San Mateo County, California. Ralph Arnold, collector; Monterey formation, middle Miocene.

From *Cytherea diabloensis* Anderson[11] it is distinguished by its more gibbose form, more equilateral and elongate shape. Since *A.* (?) *locli* has been found only in complete individuals, the dentition is unknown. It is upon the external characters alone that the species has been referred to the genus *Amiantis.*

Named in honor of Mr. Wayne Loel, who has carried on extended studies of Miocene stratigraphy in California.

TIVELA (?) VAQUEROSENSIS Wiedey, n. sp.
Plate 33, fig. 1

Shell very large, ponderous, somewhat subtriangular, very convex, slightly inequilateral; anterior margin not long, nearly straight, broadly and evenly rounded at extremity; basal margin very gently rounded, quite long; posterior extremity more sharply rounded than anterior; posterior margin rather long and quite straight; umbonal area broadly elevated and evenly rounded; beaks not conspicuous, inturned; lunular area obscured, but escutcheon long, very broad and deep; faint ridges perceptible in posterior areas of valves, adjacent to posterior margins, from beaks to shell extremity; shell sculptured by low, irregularly rounded, closely spaced, concentric ridgelets, more prominent on the umbonal areas; basal margins thick. Height, 75 mm.; breadth, 84 mm.; thickness, combined valves, 52 mm.

Holotype.—L. S. J. U. type collection, type No. 520, from L. S. J. U. Loc. 200. Collected at the type section of the Vaqueros formation, lower Miocene, in Los Vaqueros Valley, Monterey County, California.

[11] Anderson, F. M., Proc. Calif. Acad. Sci., 3rd ser., vol. 2, no. 2, 1905, pl. 17, figs. 83, 84.

This new species is more gibbose, less elongate and of thicker shell than the common living species of the genus on this coast, *Tivela stultorum*, found in southern and Lower California waters.

PLATYODON PIEDRAENSIS Wiedey, n. sp.
Plate 33, fig. 2

Shell of moderate size, equivalve, inequilateral, very highly gibbose, nearly as thick (combined valves) as long; hinge area not long; anterior end of shell abruptly truncated and very widely gaping; basal margin not long, gently rounded; posterior extremity lacking in type; umbones high, broad, and pointed indistinctly forward; posterior dorsal areas in combined valves form a flattened area; sculpture consists of very numerous, more or less evenly spaced, concentric laminae or ridgelets. Height, 58 mm.; breadth, 63+(20?) (the probable length of part broken away) mm.; thickness, combined valves, 58 mm.

Holotype.—L. S. J. U. type collection, type No. 521, from L. S. J. U. Loc. 441. Collected at the head of Canyon de Piedra, about five miles east of San Luis Obispo, San Luis Obispo County, California. R. B. Moran, collector; Vaqueros formation, lower Miocene.

This new species, of a genus infrequently encountered in the Tertiary marine beds of California, is of thicker shell, possesses a gaping end of much smaller proportions, and has more numerous concentric lines than *Platyodon cancellatus* Conrad,[12] from the upper Miocene to the Recent.

[12] Clark, Bruce L., and Arnold, Ralph, Univ. of Calif. Publ., Bull. Dept. Geol. Sci., vol. 14, no. 5, 1923, pl. 16, fig. 4.

A NEW BRACHIOPOD FROM THE SILURIAN OF CENTRAL PENNSYLVANIA

EDWARD R. BARNSLEY, B. S.
Newtown, Bucks County, Pennsylvania

The writer, in measuring a section of Silurian rocks near Lewistown, Pennsylvania, discovered a new species of the genus *Dalmanella* for which is suggested the name *D. egani.*

The fossil is confined to the upper four feet of the Keefer sandstone which is about forty feet thick at this place and lies at the base of the Rochester formation. Associated with it were found specimens of *Camarotoechia neglecta, Leptaena rhomboidalis* (?), *Stropheodonta corrugata, Meristina* sp., and *Dalmanites limulurus.*

DALMANELLA EGANI Barnsley, n. sp.

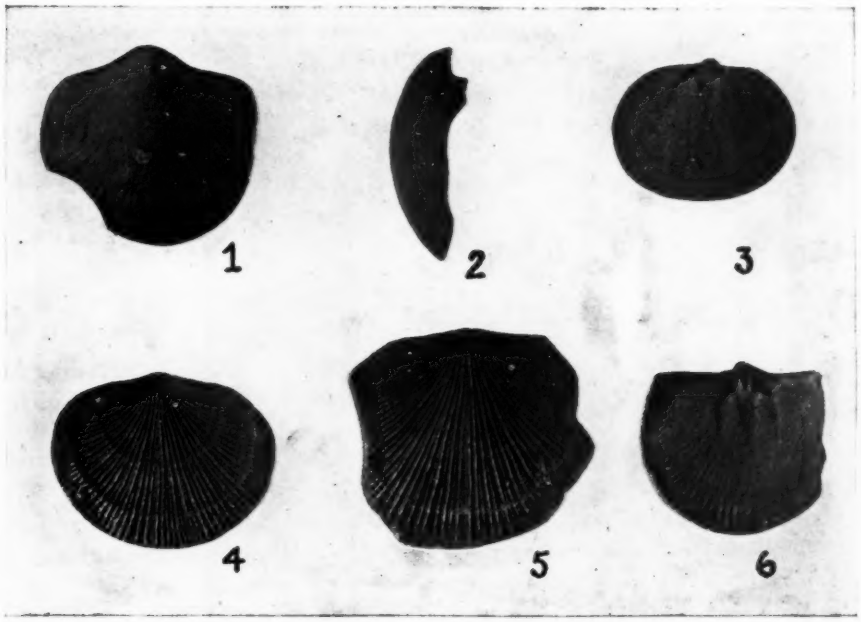
Shell of medium size, sub-plano-convex, and ovoid in outline. Hinge line straight and shorter than the greatest width of shell. Ventral valve regularly convex but sometimes showing slight arcuations along the median line. Greatest convexity usually at about one third the length of the shell in front of the beak. Beak blunt, incurved and somewhat extended. Cardinal area small and shorter than width of hinge line. Dorsal valve depressed—convex, nearly flat, with a broad, poorly defined, shallow sinus. Surface ornamented by fine rather regular ribs which generally bifurcate once, or rarely twice, and which become strongly curved outward on the slopes toward the cardinal angle. The three central ribs are weaker than the rest and are bunched together, as is well shown by figures 1, 4, and 5. The first rib on either side of these three is unforked, but all the rest fork. This feature is entirely absent in *D. elegantula,* its closest related described species.

Dimensions in millimeters of average large size individual: ventral

valve, length 10, width 11, convexity 3; dorsal valve, length 12, width 16.

Occurs 4½ miles north of Lewistown, Mifflin County, Pennsylvania in Manns Narrows where Jacks Creek flows through Jacks Mountain.

Disposition of type, U. S. National Museum, Washington. Named after a local geologist, Charles Egan, of Petrolia, Ontario.



FIGS. 1–6.—*Dalmanella egani* Barnsley, n. sp. ×2. Fig. 1, exterior of ventral valve; fig. 2, side view of same; fig. 3, cast of interior of ventral valve; fig. 4, exterior of dorsal valve; fig. 5, same of a large specimen; fig. 6, cast of interior of dorsal valve.

A CORRECTION OF GENERIC AND SPECIFIC NAMES

By ROBERT ROTH
Bartlesville, Oklahoma

In a recent paper of mine on "A Revision of the Ostracod Genus Kirkbya and Subgenus Amphissites",[1] certain important errors have been brought to my attention by Dr. Raymond C. Moore of the University of Kansas. Dr. Moore pointed out that some of the specific names do not agree with the gender of the genus. Therefore, I take this liberty of correcting and emending such of these names as require it. A check list of the changes is as follows:

Kirkbya inornatum should be *inornata.*
magnum should be *magna.*
arcuatum should be *arcuata.*
distends should be *distenta.*
tumidus should be *tumida.*
Amphissites simplexus should be *simplus.*
costatum should be *costatus.*
geni should be *geneae.*
minuta should be *minutus.*
marginifera should be *marginiferus.*
mesocosta should be *mesocostus.*
nodosum should be *nodosus.*
oblonga should be *oblongus.*
centronota transversa should be *centronotus transversus.*
oblonga transversa should be *oblongus transversus.*
permiana should be *permianus.*
parallela should be *parallelus.*
reflexa should be *reflexus.*
subquadrata should be *subquadratus.*
tricollina should be *tricollinus.*
Graphiadactyllis should be *Graphiodactylus.*

[1] Publications of the Wagner Free Institute of Science, vol. 1, pp. 1-55 (1929).

SOME NOTES ON THE OSTRACODE GRAPHIODACTYLUS ROTH

By ROBERT ROTH
Bartlesville, Oklahoma

In a recent paper on "A Revision of the Ostracod Genus Kirkbya and Subgenus Amphissites",[1] the author institutes the genus *Graphiodactylus* (improperly designated *Graphiadactyllis*). This genus was made to include the form *Kirkbya lindahli* var. *arkansana* Girty, which was first described by Dr. Girty in the Annals of the N. Y. Academy of Sciences, vol. 20, part II, 1910, and first figured by P. V. Roundy in Professional Paper No. 146, U. S. G. S. My reasons for substituting this genus are briefly stated on page 10 of the above mentioned revision.

A brief description of the genus is as follows: General outline subrectangular with a very pronounced backward swing; anterior portion of the carapace much sharper than the posterior. The individual species vary from short and tumid to quite long and slim. The maximum breadth is in the anterior quarter and the maximum height in the posterior quarter. In some forms there is a slight transverse depression running from the dorsal to the ventral margin, about midway between the anterior and posterior extremities. Valvular overlap is very pronounced, the right valve being completely rabbetted on all the margins to receive the left. The dentition is similar to that of *Kirkbya* in that the left valve contains the teeth, which are very prominent. The difference between *Graphiodactylus* and *Kirkbya* lies in the fact that the right valve very prominently overlaps the left in the region of the cardinal angles, thereby completely covering the teeth of the left valve, which is not the case in *Kirkbya*. The surface ornaments of this genus are exceedingly interesting and are very characteristic. False keels are well represented. These keels are present as a frill starting at the middle of the ventral margin where

[1] Publications of the Wagner Free Institute of Science, vol 1, pp. 1-55 (1929).

this margin is slightly concave, thence running posteriorly to the middle portion of the posterior extremity. The anterior portion of this frill gently merges into the valve; while in well preserved forms it is noted that the posterior termination is marked by a decided horn. This frill is so close to the free margin that it is only discernible after careful observation. It is present to a varying degree in all the species studied. There are no true nodes. Other ornaments upon the carapace consist of a number of minute papillae, which are most prominent upon the anterior extremity and anterior dorsal portion of each valve. In many cases one or more of these papillae attain great enough importance so that they may be called a horn. Some of the species show the papillae scattered over the entire carapace. This, however, is quite rare. The horn above mentioned, which is usually present, may be found in the anterior dorsal portion. The general ornaments covering the entire carapace are minute, bifurcating, and inosculating riblets. These are extremely variable and may be found in all manner of design and development. They are greatly affected by weathering. Their general appearance bears a surprising resemblance to finger-prints, that is, as if the carapace had been picked up between the thumb and index finger while in a plastic state. No true pit has been found, although its position may usually be inferred by the relative faintness of the riblets. In many cases the general trend of the riblets is altered in the vicinity of the "pit", as they have a tendency to be drawn into this area.

Genotype, *Graphiodactylus arkansana* (GIRTY) from the Fayetteville shale, upper Mississippian, of northwestern Arkansas and northeastern Oklahoma. Range, Kinderhook (Sycamore limestone), Mississippian, to Marmaton, Pennsylvanian.

This genus has a long geologic range, as it has been found from the Kinderhook to the Marmaton. I have found many specimens in the Sycamore limestone in several localities, one of them being in the upper contact of the Sycamore limestone in sec. 2, T. 2 N., R. 6 E., Oklahoma. Again, in the Chester they are quite abundant. In the marly breaks in the Fayetteville limestone NE/c sec. 25 T. 20 N., R. 19 E., Oklahoma, they have been found in great numbers. They are also present in the Atoka formation NE/c sec. 10 T. 5 N., R. 21 E., Oklahoma. One very large form has been found in the Wewoka. The observed modifications of this shell should probably be designated as varieties of *G. arkansana;* they are numerous and the individual variation is hardly sufficient to make desirable the erection of new species.

THREE NEW SPECIFIC NAMES FOR WEST AMERICAN FOSSIL MOLLUSCA

By LEO GEORGE HERTLEIN
California Academy of Sciences, San Francisco

OSTREA ERICI Hertlein, n. sp.

Ostrea tayloriana GABB, JORDAN and HERTLEIN, Proc. Calif. Acad. Sci., 4th ser., vol. 15, no. 14, 1926, p. 428, pl. 33, fig. 3; "mouth of large arroyo northwest of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California"; Pliocene. Not *Ostrea tayloriana* GABB, Geol. Surv. Calif. Pal., vol. 2, 1869, p. 34, pl. 12, figs. 60, 60 *a*; "Miocene, San Marcos Pass, California".

Shell moderately thick; sub-oval in outline; beaks sub-terminal; ligament pits sub-triangular. Right valve moderately convex, shell slopes obliquely from the umbones to the anterior margin, smooth except for projecting edges of shell lamellae; margins of shell rather thin. Left valve moderately heavy, ovate in outline, slightly concave; edges of shell layers give a rather rough appearance to the shell, otherwise without ornament. Height, 94 mm.; width, 71 mm.; thickness, 36 mm.

Holotype.—No. 2094 (Calif. Acad. Sci. Type Coll.) from "mouth of large arroyo northwest of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California"; Pliocene; B. F. Hake Coll.

At the time of the reported occurrence of *Ostrea tayloriana* Gabb in the Pliocene of Lower California by Jordan and Hertlein, the type specimen of that species had not been seen. This has since been found in the University of California and a comparison of it with the Lower California specimen discloses specific differences between the two. For the latter the writer proposes the name *Ostrea erici* in honor of the late Eric Knight Jordan, formerly Assistant Curator of Paleontology, California Academy of Sciences.

CUCULLAEA GROSSAFORMA Hertlein, n. n.

Cucullaea ponderosa WHITEAVES, Geol. Surv. Canada, Mesozoic Fossils, vol. 1, pt. 4, 1900, p. 294, pl. 38, figs. 1, 1 *a;* Cretaceous "Skidegate Channel west of Alliford Bay", Queen Charlotte Islands, Canada. Not *Cucullaea ponderosa* HUTTON, Catalog Tertiary Mollusca and Echinodermata of New Zealand, Wellington, 1873, p. 27; Recent, New Zealand.

Whiteaves described a species from the Cretaceous of Canada as *Cucullaea ponderosa* and later suggested[1] that it might be only a variety of *C. truncata* Gabb;[2] however, Packard[3] in 1922 recognized Whiteaves' species as valid; apparently this action was entirely justifiable. It is therefore necessary to provide the west American form with another name because Hutton had alrady used *"Cucullaea ponderosa"* for a different species found living in New Zealand; *Cucullaea grossaforma* is proposed.

PECTEN (CHLAMYS) GRUNSKYI Hertlein, n. sp.

1917. *Pecten branneri* ARNOLD, DICKERSON, Proc. Calif. Acad. Sci.; Fourth Series, vol. 7, no. 6, July 30, 1917, p. 160, pl. 28, fig. 2. "On the east bank of the Cowlitz River just back of the Greeco ranch house, about four miles east of Vader, Washington", Lower Oligocene according to Dickerson. Not *Pecten (Chlamys) branneri* ARNOLD, U. S. Geol. Survey, Prof. Paper 47, 1906, p. 55, pl. 3, figs. 9, 10 and 11, "Tuff Hill, near Stanford University", Lower Miocene.

Shell rather small, higher than long, equilateral, thin flattish; sides straight, base rounded; surface ornamented by 35 to 40 fine, low, rounded ribs, separated from each other by slightly wider interspaces, some of the ribs occur in pairs which on the umbo form a single rib; a few fine midribs are present but these disappear in the earlier part of the shell; a fine tessalate sculpture is present on unweathered portions of the interspaces and ribs, otherwise the surface of the shell is ornamented only by very fine imbricating lines of growth. Anterior ear large with a deep byssal notch, ctenolium present on margin of shell near ear, about 6 to 8 radial ribs crossed by imbricating lines of growth ornament the anterior ear; posterior ear ornamented by about 6 to 8 subequal radial ribs which are crossed by concentric lines of growth. Altitude of right valve 24 mm.; longitude (approximately) 22 mm.; thickness (approximately) 1 mm.; apical angle about 90°.

Holotype.—Right valve, No. 424, Calif. Acad. Sci. Coll., from Loc. 181 (C. A. S.), on the east bank of the Cowlitz River just back of the

[1] Geol. Surv. Canada, Mesozoic Fossils, vol. 1, pt. 5, 1903, p. 394.
[2] Geol. Surv. Calif. Palaeo., vol. 1, 1864, p. 196, pl. 25, fig. 182.
[3] Univ. Calif. Pub. Geol., vol. 9, no. 12, 1916, p. 146.

Greeco ranch house, about four miles east of Vader, Washington; Frank M. Anderson and Bruce Martin, collectors; "Lower Oligocene", possibly upper Eocene.

This species is smaller, and possesses more numerous, low, rounded ribs which lack the spiny sculpture found on *Pecten (Chlamys) branneri* Arnold.

Pecten (Chlamys) landesi Arnold[4] is more circular in outline, more ventricose, and the apical angle is much greater than is the case in the present species.

In a report dealing with the fossil Mollusca found at Loc. 181 (C. A. S.) on the Cowlitz River, Washington, Dickerson listed and figured a species as *Pecten branneri* Arnold. A study of that specimen indicates that it cannot be referred to Arnold's species and it is accordingly described as *Pecten (Chlamys) grunskyi* in honor of Dr. C. E. Grunsky, President of the California Academy of Sciences.

[4] U. S. Geol. Survey, Prof. Paper 47, 1906, p. 51, pl. 2, figs. 3, 4 and 5. "Vicinity of Little Falls, Lewis County, Wash." Eocene.

FOSSIL FRUITS IN THE ANCON SANDSTONE OF ECUADOR

By EDWARD W. BERRY
Johns Hopkins University, Baltimore, Maryland

About a year ago Dr. George Sheppard of the Anglo Ecuadorian Oilfields, Ltd., sent me some specimens of fruits from the Ancon Point sandstone at Ancon Point, Sta Elena peninsula, Ecuador. The exact locality is Ida Seca.

The Ancon Point sandstone comprises coarse, poorly sorted and rapidly deposited sediments, and the contained plant fossils are poorly preserved. It contains fragments of lignitic material, sandy clay galls, and a considerable variety of fruits and seeds. In addition to the following named species there are at least six additional which I do not recognize, and which are not sufficiently well preserved to warrant identification.

These fruits are of considerable interest in their bearing on the environmental conditions at the time that the Ancon Point sandstone was deposited, and also on its correlation with the more complete section of the petroliferous region of northwestern Peru. Four of the identified species from Ida Seca, namely: *Anacardium peruvianum, Palmocarpon bravoi, Sapindoides peruvianus* and *Anona peruviana* are present in Peru at the locality known as Belen which is about 6 miles southeast of Pta Parinas, where a large variety of fruits and seeds are found in an excellently silicified condition. *Anacardium peruvianum* occurs also in Colombia, and the new species of Vantanea from Ancon Point is close to a Colombian species and is represented at Belen, Peru, by a related species in the same genus.

It seems rather clear that the Ecuadorian and Peruvian horizons must be nearly the same age. In my original description of the seeds

from Belen I gave their age as Oligocene on the authority of A. A. Olsson who had collected most of the material and was familiar with the local geology and marine faunas. A visit to the locality and other considerations lead me to think that the age is not Oligocene but Eocene. This would bring it in agreement with the supposed age of the Ancon Point sandstone of Ecuador and the plant beds in the Guaduas formation of Colombia, which latter Anderson, Scheibe, and Stutzer all regard as Eocene. This question will be considered in detail in an account of my Peruvian collections which is being prepared.

PALMOCARPON BRAVOI Berry

Palmocarpon bravoi BERRY, Pan Amer. Geol., vol. 47, 1927, p. 123, pl. 19, figs. 7, 8.

This species was described from Belen, Peru, where it is abundant. Although the Ecuadorian specimens are larger than the type, I can see no convincing reason for considering them to represent a different species. It was remarked in the original account that they showed some variation in size and much variation in form, and I have since collected nearly as large specimens from the type locality as those found in Ecuador. The latter comprise four specimens, all more or less deformed, and all relatively large, having a maximum diameter in their deformed condition of about 1.5 centimeters.

ANONA PERUVIANA Berry

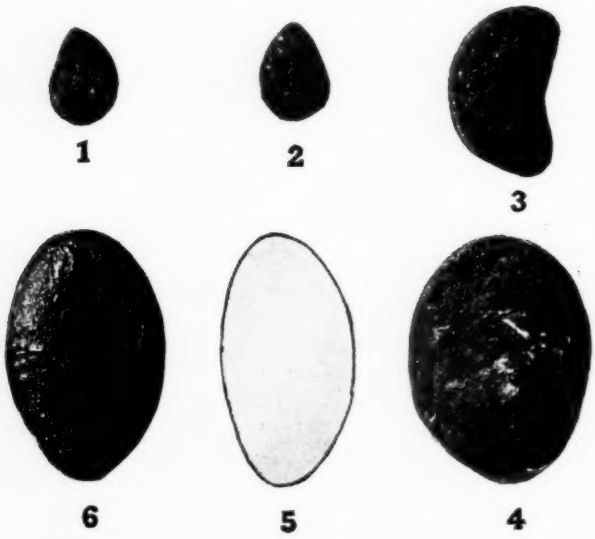
Carpolithus peruvianus BERRY, Pan Amer. Geol., vol. 47, 1927, p. 131, pl. 19, fig. 4.

The type locality for these seeds was Belen, Peru, and at the time that they were described their botanical affinity was not recognized, and certain resemblances to the seeds of *Diospyros* and *Theobroma* were pointed out. I have since recognized their relationship to the seeds of the largely American genus *Anona*, or *Annona* as the purists prefer to spell it. Among the upwards of sixty existing species of *Anona* I have seen the seeds of but a very few, and among those seen the present fossil seeds are most similar to those of *Anona cherimolia* Miller—the well known chirimoya of the South American tropics. The latter is essentially a species of dry warm habitats, but it does not follow that such was the environment of the fossil, since many existing Anonas are wet soil forms. The Ecuadorian material consists of a single characteristic specimen.

VANTANEA SHEPPARDI Berry, n. sp.
Figs. 4, 5

Stone large, ligneous, somewhat compressed, symmetrically elliptical in side and end view, slightly asymmetric in edge view. Slightly more broadly rounded at the distal than at the chalazal end. Length 3.2 centimeters; maximum width 2.4 centimeters; maximum thickness 1.75 centimeters. Surface somewhat roughly fibrous in appearance, not smooth, nor does it show any pits or resin cavities.

Two other fossil species of *Vantanea* have been described by the



FIGS. 1, 2.—*Sapindoides peruvianus* Berry.
3.—*Anacardium peruvianum* Berry.
4.—*Vantanea sheppardi* Berry, n. sp., surface view.
5.—Same, lateral profile.
6.—A recent *Ventanea, V. cupularis.*
(All natural size.)

present writer—one based upon leaves from the lower Eocene (Wilcox) of southeastern North America[1] and the other on stones from Cipacon, Department of Cundinamarca, Colombia.[2] The present species from Ecuador is very close to the latter—*Vantanea colombiana.* It is also very similar to the stones of the existing *Vantanea cupularis,* which is the only existing species whose fruits have been accessible to me.

[1] Berry, Edward W., U. S. Geol. Survey Prof. Paper 91, 1916, p. 255, pl. 54, fig. 6.
[2] Berry, Edward W., Pan. Amer. Geol., vol. 42, 1924, p. 259, fig. 3.

Vantanea sheppardi appears to be distinct from *Vantanea colombiana* in its more gibbous form and in the absence of the resin cavities which are normally present in that species. It differs from the stones of *Vantanea cupularis* merely in its more gibbous form. The species is named for the collector—Dr. George Sheppard. An undescribed species of *Vantanea* stone occurs at Belen, Peru.

SAPINDOIDES PERUVIANUS Berry
Figs. 1, 2

Sapindoides peruvianus BERRY, Pan Amer. Geol., vol. 47, 1927, p. 126, fig. 9.

This species was described from Belen, Peru, and appears to be represented by two specimens from the Ancon Point sandstone of western Ecuador. These add nothing to our understanding of the species, which evidently belongs to some member of the family Sapindaceae.

ANACARDIUM PERUVIANUM Berry
Fig. 3

Anacardium peruvianum BERRY, Am. Jour. Sci., vol. 8, 1924, p. 124, figs. 1-8.

This species was described from Belen, Peru, where it is present in great abundance in a silicified condition, and exhibiting very considerable variation in both size and form. The Peruvian material sometimes shows part of the ligneous exocarp, the lining secretory layer, and other details in an unmistakable manner, and agrees exactly with the existing Cashew nut in its organization. A single specimen was referred to this species from near Leiva, Department of Boyaca, Colombia.

A second and larger fossil species has been described from the middle Eocene of Colombia,[3] and a third species has been discovered recently in the lower Eocene (Wilcox) of Texas. The material from the Ancon Point sandstone of Ecuador comprises three specimens ranging from 2.1 to 2.5 centimeters in length. The degree of curvature of the seeds is somewhat less than the normal for the modern Cashew, or the average for the Peruvian material, but in the latter there are occasional specimens identical with those from Ecuador, so that I have no hesitation in referring the Ecuadorian specimens to the same botanical species.

[3] Berry, Edward W., Pan. Amer. Geol., vol. 42, 1924, p. 261, figs. 1, 2.

SOME RECENT SHALLOW WATER FORAMINIFERA DREDGED NEAR SANTA CATALINA ISLAND, CALIFORNIA

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During the year 1927, Mr. A. M. Strong of Los Angeles did considerable dredging in the shallower portions of the San Pedro Channel off Whites' Landing, Santa Catalina Island, for the purpose of obtaining species of small mollusca. The dredge used was small and of the drag type so that good hauls of bottom sediments were secured. The material thus obtained was washed through a coarse screen which retained not only the small mollusca but numerous species of foraminifera as well. Due to the coarseness of the screen only those foraminifera of large size were saved. They were picked out by Mr. Strong and very kindly donated to Dr. G. D. Hanna of the California Academy of Sciences. It is to these two men that the writer is indebted for the material described in this paper.

Because of the meager knowledge concerning the foraminifera of the shallower portions of this important area it has seemed advisable to publish on the present species although many smaller forms undoubtedly associated with them are missing.

A complete synonomy is not attempted here as some few of the more recent and well known works is considered sufficient in a paper of this kind.

AMMODISCUS INCERTUS (d'Orbigny)

Ammodiscus incertus (D'ORBIGNY), H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 330, pl. 38, figs. 1-3.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 1, 1910, p. 73, figs. 95-96 (in text).

This is one of the most common and best developed species found in this general region and many good specimens were obtained. It

is very well developed as are the many other arenaceous forms found in the area under similar living conditions. The arenaceous foraminifera undoubtedly form a most conspicuous part of this shallow water fauna.

PYRGO RINGENS (Lamarck)

Biloculina ringens (LAMARCK), WILLIAMSON, 1858, Recent Foram. Great Britain, p. 79, pl. 7, figs. 169-171.—R. M. BAGG, U. S. Geol. Surv. Bull. 513, 1912, p. 25, pl. 1, figs. 5-9, 11-16; pl. 3, figs. 1-3.

Only one good specimen of this species was obtained but it is well developed; length, 1 mm.

CORNUSPIRA FOLIACEA (Philippi)

Cornuspira foliacea (PHILIPPI), CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 24, pl. 1, fig. 1; pl. 2, fig. 1.

Only one good specimen of this form was saved but it is typical of the species and is one of the common forms found along the Pacific Coast.

DISCORBIS REPANDA (Fichtel and Moll)

Pulvinulina repanda (FICHTEL and MOLL), BAGG, U. S. Geol. Surv. Bull. no. 513, 1912, p. 87, pl. 24, figs. 5-8.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 50, pl. 24, fig. 3.

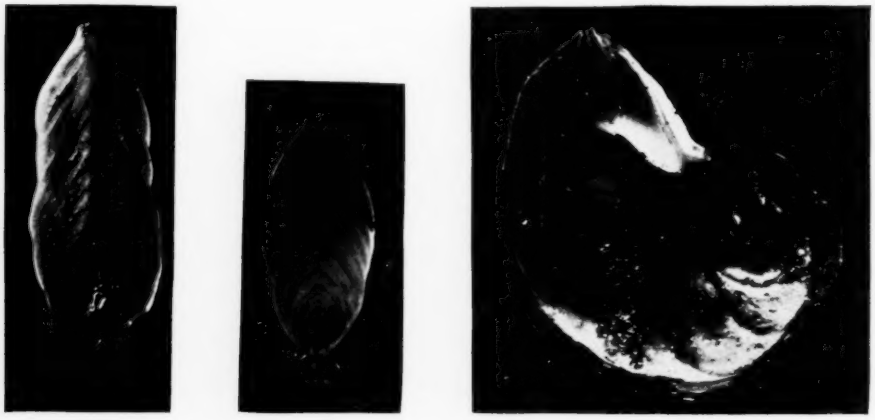
This is one of the common forms found in the shallower waters of this region and several good specimens were secured. It is variable in size and in the nature and amount of extraneous growth about the umbilical area but the general features remain the same. It is a strong, heavy form.

FRONDICULARIA GIGAS Church, n. sp.
Figs. 1, 2

Test very large, flattened, elongate, about twice as long as broad in adult specimens, initial end broadly rounded to tapering, periphery rounded, two to three coarse spines growing from the initial end extending out in a plane parallel to the flattened plane of the test; dimorphism well demonstrated, the microspheric form planospiral in the early stages, the chambers extending back in an inverted 'V' shape after the fifth or sixth added chamber; the megalospheric form has a large spherical proloculum and the intermediate coiled stage is absent; chambers vary in number, 20 in adult type, first few

flattened, later ones becoming slightly inflated; sutures distinct somewhat depressed in final stages; wall smooth except for slightly raised sutures in early stage and depressed ones in later, calcareous, thick, vitreous, polished and finely perforate; aperture terminal and radiate becoming more open in late stage of development. Length of type specimen, 7 mm.; width, 3 mm. Other specimens vary from 5 mm. in length and 2 mm. wide to 3 mm. in length and 1.5 mm. wide.

Holotype.—California Academy of Sciences No. 4700 taken off Whites' Landing, Santa Catalina Island, California, in 30-40 fathoms by A. M. Strong. *Paratypes.*—Nos. 4701, 4702, 4703.



1 2 3

FIG. 1.—*Frondicularia gigas* Church, n. sp. Holotype, C. A. S. No. 4700. Microspheric form.
2.—Same. Megalospheric form. C. A. S. No. 4701.
3.—*Robulus strongi* Church, n. sp. Holotype, C. A. S. No. 4704.

HAPLOPHRAGMOIDES ADVENA Cushman

Haplophragmoides advena CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 38, pl. 6, figs. 1 *a*, *b*.—G. D. HANNA and C. C. CHURCH, Jour. Paleon., vol. 1, no. 3, Dec., 1927, p. 198.—CUSHMAN, Bull. Scripps Inst. Oceanog., Tech. Ser., vol. 1, no. 10, 1927, p. 135.

This is one of the common forms found in the shallower waters of this area and previous records indicate its presence from British Columbia to southern California.

NODOSARIA OBLIQUA (Linnaeus)

Nodosaria obliqua (LINNAEUS), BAGG, U. S. Geol. Bull. 513, 1912, p. 57, pl. 15, figs. 1 *a-d;* pl. 17, figs. 1 *a-d.*—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 59, pl. 25, fig. 5.

The single good specimen found is of large size and more closely resembles the figures given by Bagg. The test is curved and the final chamber is practically smooth, the preceding ones being strongly ribbed and less inflated.

ROBULUS STRONGI Church, n. sp.

Fig. 3

Test large, compressed, keeled, length greater than width with slight tendency toward uncoiling; surface highly polished and uneven; 13 chambers visible, depressed and gently curved; suture lines well developed, curved and raised visibly above general surface of test, blending with the clear shell material of the keel in the initial chambers and lower half of test, less prominent, even depressed, in final chambers; wall relatively thick, calcareous, polished, perforations not visible; aperture radiate with the proximal radial slit enlarged and extending into the apertural face; apertural face twisted to one side so that one edge meets the keel at the base of the last formed chamber. Length of type, 4.5 mm.; width, 3 mm.; average somewhat smaller. The species closely resembles *Cristellaria occidentalis* var. *novangliae* Cushman, from the Atlantic coast.

Holotype.—California Academy of Sciences, No. 4704, taken off Whites' Landing, Santa Catalina Island, California in 30-40 fathoms, by A. M. Strong. *Paratypes.*—Nos. 4705, 4706, 4707, 4708.

The species has been named for Mr. A. M. Strong, Conchologist.

A NOTE ON THE OCCURRENCE OF PATELLINA CORRUGATA WILLIAMSON IN THE SAN JUAN ARCHIPELAGO, WASHINGTON

By DOROTHY K. PALMER
Scripps Institution of Oceanography, La Jolla, California

ABSTRACT

Four specimens of *P. corrugata* Williamson from off San Juan Island, Washington, constitute the first record of this species in the eastern North Pacific.

The discovery that *Patellina corrugata* Williamson is living in the San Juan Archipelago, Washington, is not unexpected, for it ranges widely. It was originally reported by Williamson[1] from Scotland and from Davis Strait, eastern Canada. Dr. Cushman found it at Woods Hole[2] and in Richmond Gulf on the east coast of Hudson Bay,[3] represented by a single specimen at each locality. The species was reported by Brady[4] from the shores of western Europe and the Mediterranean; the North Atlantic and the Arctic, occurring in the latter ocean at the most northerly sounding of the Nares North-Polar Expedition, lat. 83° 19′ N. It is present in the South Atlantic in the vicinity of the Falkland Islands and at Tristan d'Acunha;[4] in the Indian Ocean at Mauritius, Kerguelen,[5] and in the Kerimba[6] and Malay Archipelagoes;[7] in the South Pacific off New Zealand[8] and in

[1] Williamson, W. C., Recent Foraminifera of Great Britain, 1858, p. 46, pl. 3, figs. 86-89.
[2] Cushman, J. A., Foraminifera of the Woods Hole Region. Proc. Boston Soc. Nat. Hist., vol. 34, no. 2, 1908, p. 29, pl. 5, fig. 3.
[3] Cushman, J. A., Results of the Hudson Bay Expedition, 1920, I. Foraminifera. Cont. Can. Biol., Univ. Toronto Press, 1922, p. 11.
[4] Brady, H. B., Rept. Voy. Challenger, Zoology, vol. 9, 1884, p. 634, pl. 73, figs. 2-4.
[5] Egger, J. G., Foraminiferen aus Meeresgrundproben, gelothet von 1874 bis 1876 von S. M. Sch. Gazelle, Abhand. d. k. bayer. Akad d. Wiss. II Cl. XVIII Bd., II Abth., 1893, p. (393) 201, pl. 15, figs. 70-72.
[6] Heron-Allen, E., and Earland, A., Foraminifera of the Kerimba Archipelago. Trans. Zool. Soc. Lond., vol. 20, pt. II, 1915, pp. 686-7.
[7] Millett, W. F., Rept. Recent Foraminifera of the Malay Archipelago. Journ. Roy. Micr. Soc., 1903, p. 696.
[8] Heron-Allen, E., and Earland, A., Brit. Antarctic ("Terra Nova") Exp. 1910, Foraminifera. Brit. Mus. (Nat. Hist.) Zool., vol. 6, no. 2, 1922, p. 198, pl. 7, fig. 5.

the Antarctic.[8] The majority of the records are from littoral and moderately shallow water.

But though *Patellina corrugata* is so generally distributed the number of specimens is usually very limited and it is only in the vicinity of the British Isles[9] and in the Antarctic that an abundance of specimens has been reported. The species has been particularly rare in the North Pacific, where it was found at Jolo Island, in the Philippine Archipelago[10] and at Chatham and Laysan Islands,[11] one specimen at each locality.

Four specimens of *P. corrugata* have been found in a sample dredged from 100-150 meters between Brown Island and Point Caution, just outside the entrance to Friday Harbor, San Juan Island. These constitute, therefore, the first evidence that the species is living in the shallow water of the eastern North Pacific. Foraminifera are very abundant in the collection from this region and it is possible that when the entire series of samples has been carefully examined, the species will be found to be more abundant than this preliminary announcement indicates.

The San Juan specimens are without doubt referable to Williamson's species. The conical tests are very small and fragile and are characterized by an early tubular growth followed by a rotaline plan of growth in which there are two narrow, crescentic chambers in each whorl. The chambers are partially subdivided by a few internal septa (usually 9 in each chamber in the Washington examples) which are distinctly visible, especially near the periphery. The diameter of the largest San Juan specimen is .114 mm.

The most nearly related species is *P. advena* Cushman[12] which was described from the Lower Oligocene Mint Spring calcareous marl of Vicksburg, Miss., and is living in Samoa[13] and off the Juan Fernandez Islands, west of Chile.[14] The specific distinction of the two forms lies in the fact that *P. advena* has numerous internal septa. Dr. Cushman has called attention to the fact that records of *P. corrugata* in the South Pacific probably refer to *P. advena*.[13]

[9] Heron-Allen, E., and Earland, A., Foraminifera from the west of Scotland. Trans. Linn. Soc. London, 2nd ser., Zool., vol. XI, pt. 13, 1916, p. 269.
[10] Cushman, J. A., Foraminifera of the Philippine and adjacent seas. Smith. Inst., U. S. Nat. Mus. Bul. 100, vol. 4, 1921, p. 303.
[11] Rhumbler, L., Foraminiferen von Laysan und den Chatham Inseln. Zool. Zahrb., Abth. Syst., vol. 24, 1906, p. 35.
[12] Cushman, J. A., Foraminifera of the Mint Spring calcareous marl. U. S. Geol. Survey Prof. Paper 129-F, 1922, p. 135, pl. 31, fig. 9.
[13] Cushman, J. A., Samoan Foraminifera. Carnegie Inst., Washington, Publ. 342, 1924, pp. 32-3.
[14] Cushman, J. A., and Wickenden, R. T. D., Recent Foraminifera from off Juan Fernandez Islands. Proc. U. S. Nat. Mus., vol. 75, art. 9, 1929, pp. 11-12, pl. 4, fig. 10.

SOME PENNSYLVANIAN OSTRACODA AND FORAMINIFERA FROM SOUTHERN OKLAHOMA—A CORRECTION

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In a recent monograph on "The Pennsylvanian System in the Ardmore Basin",[1] C. W. Tomlinson has questioned certain fossil localities described by the writer.[2] In reviewing the papers it is apparent that several errors were made and they are corrected below.

Changes in the sectional descriptions of microfossils are made with reference to the pages of volume one of this Journal. A number of errors in giving distances from Ardmore were made but these are not corrected. P. 18, *Bradyina holdenvillensis*, NW. ¼ of NW. ¼ of Sec. 20, T. 5 S., R. 1 E., (Anadarche limestone). *Endothyra radiata*, center of N. ½ of Sec. 14, T. 5 S., R. 1 E. P. 21, *Stacheia pupoides*, center of N. ½ of Sec. 14, T. 5 S., R. 1 E. P. 23, *Tetrataxis conica*, NE. ¼ of SE. ¼ of Sec. 7, T. 5 S., R. 1 E. P. 25, *Globigerina seminolensis*, NW. ¼ of NW. ¼ of Sec. 2, T. 5 S., R. 1 E. P. 205, *Jonesina craterigera*, center of N. ½ of Sec. 14, T. 5 S., R. 1 E. P. 210, *Bairdia glennensis*, NE. ¼ of SE. ¼ of Sec. 7, T. 5 S., R. 1 E. P. 211, *Bairdia hoxbarensis*, read Upper Glenn fauna, instead of Hoxbar.

The use of the terms Hoxbar and Deese in these papers was based on faunal range instead of formation contacts. The careful mapping by Tomlinson has permitted lithologic correlations of a much more detailed nature than was heretofore possible and has made the accurate division of formation boundaries possible. In view of this work it will be necessary to redescribe the faunal distribution at some future time and the use of the terms Hoxbar and Deese based on faunas is being revised by the micropaleontologists who are working on the area.

[1] Oklahoma Geological Survey, Bulletin 46, 1929.
[2] "Some Pennsylvanian Foraminifera of the Glenn Formation of Southern Oklahoma" and "Some Pennsylvanian Ostracoda of the Glenn and Hoxbar Formations of Southern Oklahoma and of the Upper Part of the Cisco Formation of Northern Texas", Journal of Paleontology, vol. 1, nos. 1 and 3, 1927.

SOME FORAMINIFERA FROM THE NIOBRARA AND BENTON FORMATIONS OF WYOMING

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Massachusetts Institute of Technology, Cambridge, Massachusetts

ABSTRACT

A few of the common Cretaceous species of the Benton and Niobrara formations of Wyoming are figured. Well preserved foraminifera are few and are mostly of well known species.

Very little is known about the Foraminifera of the Upper Cretaceous north of Texas, and practically nothing has been published on the micro-faunas of the Rocky Mountain region.

The literature on the Upper Cretaceous Foraminifera of this region consists mainly of two early reports, that of Ehrenberg in 1854, and Tyrrell in 1890. Ehrenberg, in his "Mikrogeologie" 1854, published one plate of American Cretaceous Foraminifera listing 27 genera and 68 species of which many of the names are now obsolete.[1] For the locality from which they were collected, Ehrenberg gives "Missouri region" and "Mississippi region" referring to the river basins and not to the states as now known. He gives no formation names.

In 1890 Joseph B. Tyrrell published a paper on "Foraminifera and Radiolaria from the Cretaceous of Manitoba",[2] in which he notes the constant presence of Foraminifera in the Niobrara formation and lists the following: *Globigerina cretacea* d'Orbigny, *Globigerina bulloides* d'Orbigny, *Orbulina universa* d'Orbigny, *Discorbina globularis* d'Orbigny, *Anomalina ammonoides* Reuss, *Anomalina arimin-*

[1] Cushman, J. A., "American Cretaceous Foraminifera Figured by Ehrenberg", 1927, Journ. Pal., vol. 1, no. 3, pp. 213-217, pls. 34-36.
[2] Tyrrell, J. B., "Foraminifera and Radiolaria from the Cretaceous of Manitoba", Trans. Roy. Soc. Canada, vol. VIII, sec. 4, 1890, pp. 111-115.

ensis d'Orbigny, *Textularia agglutinans* d'Orbigny, *Textularia agglutinans* d'Orbigny, var. *pygmea* d'Orbigny, *Textularia agglutinans* d'Orbigny, var. *porrecta* H. B. Brady, *Textularia globulosa* Ehrenberg, *Textularia turris?* d'Orbigny, *Textularia saggitula* Defrance, *Textularia sp.*, *Gaudryina pupoides* d'Orbigny, *Planorbulina sp.*, *Bulimina pupoides* d'Orbigny. In a foot-note Tyrrell adds the following species, from the Niobrara, which were identified for him by C. Davies Sherborn: *Cristellaria rotulata* Lamarck, *Planorbulina ammonoides* Reuss, *Anomalina rotula* d'Orbigny, *Bulimina variabilis* d'Orbigny, *Verneuilina triquetra* d'Orbigny, *Marginulina variabilis* Neugeboren, *Globigerina linnaeana* d'Orbigny, and *Dentalina pauperata* d'Orbigny.

There have been a few other records of Foraminifera from western Canada and the Rocky Mountain region of the United States, such as Meek and Hayden's reports in which they mention a Pennsylvanian *Fusulina*, and George M. Dawson's early reports on the Forty-ninth Parallel Survey. These reports, however, are usually too brief and lacking in specific names for the most part. Cushman, "Some Foraminifera from the Cretaceous of Canada" (Trans. Roy. Soc. Canada, sec. IV, 1927, pp. 127-132, pl. 1), describes and figures a number of species from Western Canada.

During the summer of 1928, I collected several thousand samples of sedimentary rocks from various localities in Wyoming and Colorado, hoping to find enough Foraminifera in them to start a rough geologic column from Paleozoic to Quaternary. However, most of the rocks were too indurated to break down and wash satisfactorily, and too many samples were entirely barren of micro-fossils to allow such an undertaking. As an example, out of fifty washings, one or possibly two samples would be found to contain a few poorly preserved Foraminifera. The best samples, on which the following notes are written, were taken from the Benton and Niobrara formations on the east flank of the Centennial Syncline on the west slope of Sheep Mountain, T. 15 N., R. 77 W., a few miles east of Centennial, Wyoming.

The Benton here is a jet black shale, fairly soft, carbonaceous, and conformable upon the underlying Dakota sandstone. Near the base of the formation is the harder, gray, "fish-scale" Mowry member, bearing no Foraminifera in any of the samples. The total Benton thickness here is about a thousand feet. Conformably upon the Benton is about four hundred feet of impure chalky limestone and shale comprising the Niobrara formation. On account of its hardness and yellow color, it forms noticeable small ridges along the

gently sloping foot of Sheep Mountain. The richest samples from the Niobrara were from the lower part in the zones of *Inoceramus deformis* and *Ostrea congesta*, while the only good Benton samples were well up toward the top of the formation.

Work on this material has been carried on at the Cushman Laboratory for Foraminiferal Research, and at the Massachusetts Institute of Technology under the direction of Dr. Joseph A. Cushman. The writer is greatly indebted to Dr. Cushman for his many helpful suggestions and his aid in determining the species described in these notes. I am also indebted to Dr. S. H. Knight of the University of Wyoming for helpful suggestions for collecting this material in the field.

All of the Foraminifera from the Niobrara are calcite casts so that identification by surface ornamentation and apertures has been impossible. Those from the Benton have retained the external tests.

The figured specimens and types are in the collection of the Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts.

Family TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA BENTONENSIS Carman, n. sp.

Plate 34, figs. 8, 9

Test minute with the early chambers planispiral, later becoming biserial, the biserial portion making up the larger part of the test; sutures slightly oblique, rather indistinct; sides nearly parallel; apertural end sub-acute; wall arenaceous with much brown cement; aperture in the biserial portion a narrow slit on the inner margin of the last-formed chamber. Length of holotype, 0.50 mm.; breadth, 0.15 mm.

Holotype.—(Cushman Coll. No. 11968) from Cretaceous, Benton shale, East flank of Centennial Syncline, West slope of Sheep Mountain, T. 15 N.; R. 77 W.; East of Centennial, Wyoming.

Family HETEROHELICIDAE

Genus GÜMBELINA Egger, 1899

GÜMBELINA GLOBIFERA (Reuss)

Plate 34, fig. 3

Textularia globifera REUSS, Sitz. k. Ak. Wiss. Wien, vol. 40, 1860, p. 232, pl. XIII, figs. 7 *a*, *b*, 8.

Test long and very tapering, early chambers planispiral, later ones biserial, chambers enlarging more regularly and more gradually than in *G. globulosa*, 6—9 chambers on each side, last few chambers nearly perfect spheres. Benton.

In many Benton specimens the last chamber protrudes to one side and is much inflated. This is probably an advanced adult stage preparatory to its taking on the early three chambered stage of *Ventilabrella*. A doubtful new name, *Gümbelina ultimatumida* of White (Journ. Pal., vol. 3, 1929, p. 39) was given such forms but it is probably not of specific value as other species and especially the young of *Ventilabrella* show similar stages.

GÜMBELINA GLOBULOSA (Ehrenberg)
Plate 34, figs. 10-20

Textularia globulosa EHRENBERG, Abhandl. k. Ak. Wiss. Berlin, 1838, p. 135, pl. IV, fig. B, frequens.

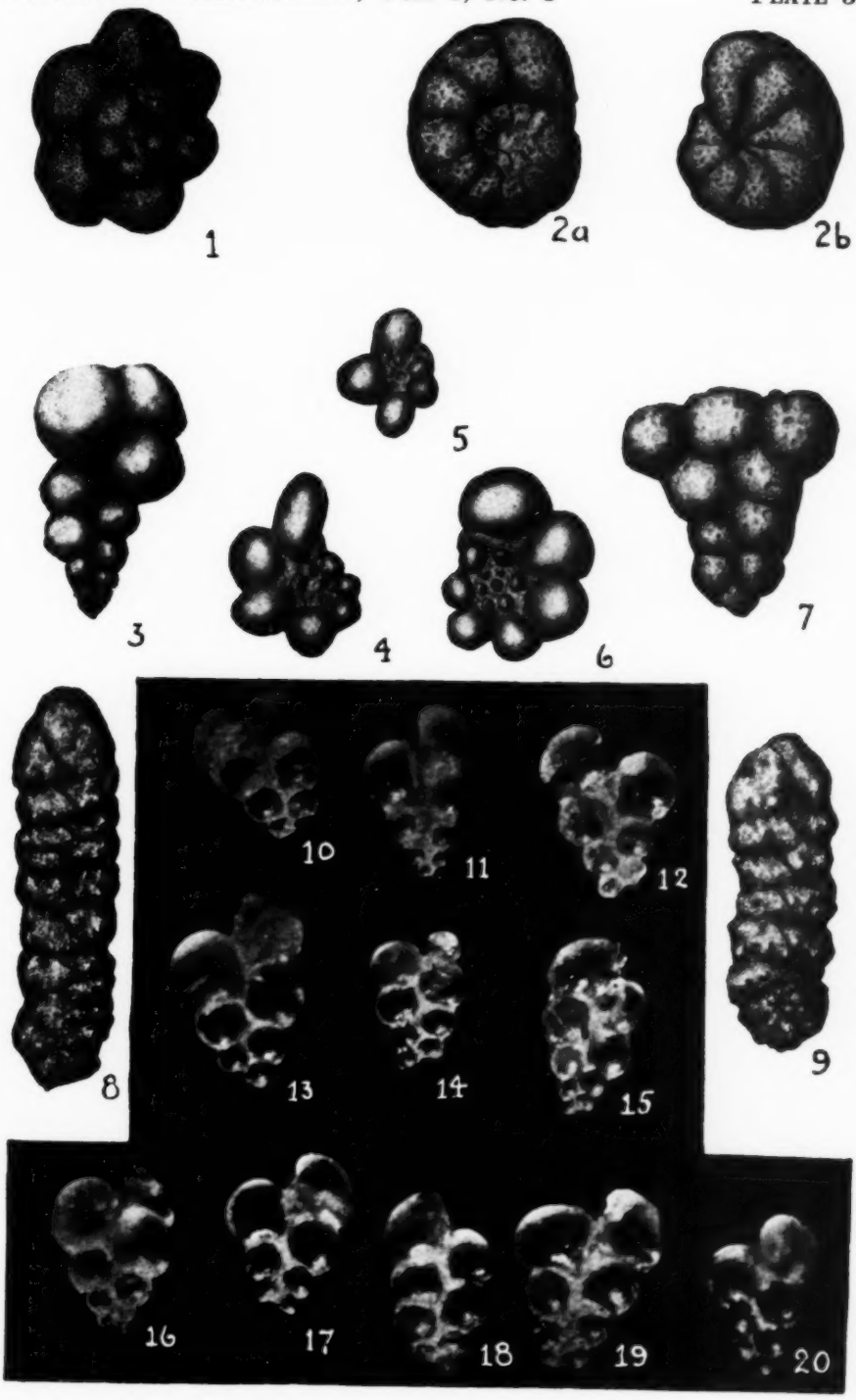
Test short and broad, biserial, rapidly widening, 3—5 chambers on each side (exclusive of proloculum), last-formed chambers very globose.

These specimens look so much like Reuss' figure of *Textularia globifera* (Sitz. Akad. Wiss. Wien, vol. 40, 1860, pl. XIII, fig. 8) of the shorter type that it is difficult to place the species. However, none of these specimens show any very early chambers; hence, the casts in their present state, have been identified as *Gümbelina globulosa*, which, in Ehrenberg's figure, *Textularia globulosa*, commences with early chambers of large size. Whether these Niobrara forms have lost the proloculum in washing, or whether the calcite which made the casts did not percolate into the smallest chambers, it is impossible to say.

Niobrara.

EXPLANATION OF PLATE 34

FIG. 1.—*Globigerina cretacea* d'Orbigny. (From photograph.) ×45.
2 *a*, *b*.—*Anomalina* sp. (?). *a*, dorsal; *b*, ventral view. ×65.
3.—*Gümbelina globifera* (Reuss). (From photograph.) ×45.
4, 5.—*Globigerina subdigitata* Carman, n. sp. 4, Holotype. 5, Paratype. ×65.
6.—*Globigerinella aspera* (Ehrenberg). ×65.
7.—*Ventilabrella eggeri* Cushman. ×65.
8, 9.—*Spiroplectammina bentonensis* Carman, n. sp. 8, Holotype. 9, Paratype. ×65.
10–20.—*Gümbelina globulosa* (Ehrenberg). (From photographs.) ×45.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Genus VENTILABRELLA Cushman, 1928

VENTILABRELLA EGGERI Cushman

Plate 34, fig. 7

Gümbelina acervulinoides EGGER (in part), Abhandl. Kön. bay. Akad. Wiss. München, Cl. II, vol. 21, 1899, pl. 14, fig. 20.

Ventilabrella eggeri CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 4, 1928, p. 2, pl. 1, figs. 10-12.

Test flat, V-shaped, early stages planispiral, later biserial as in Gümbelina, last-formed chambers triserial in one plane, chambers globular, perforate.

Benton and Niobrara.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA CRETACEA d'Orbigny

Plate 34, fig. 1

Globigerina cretacea D'ORBIGNY, Mém. Soc. Géol. France, 1840, p. 34, pl. III, figs. 12, 13, 14.

Test trochoid throughout, early chambers in a flattened trochoid spire, perforate, last chambers globular, one aperture.

This is the most common species in both Niobrara and Benton, and may be divided into four varieties.

VARIETY 1

Test not compressed, with low spire, 6—7 chambers in last-formed coil, last chambers not as globular as in typical *G. cretacea*. Benton and Niobrara.

VARIETY 2

Test not compressed, with high spire sometimes forming three trochoid coils, 4—5 chambers in last-formed coil, last few chambers very globose. Benton and Niobrara.

VARIETY 3

Test compressed, periphery sub-carinate, low spire, last-formed coil nearly planispiral with 6—7 chambers. Niobrara.

VARIETY 4

Test much compressed, periphery sub-carinate, low spire, last-formed coil 3, 4, or 5 chambers. Niobrara.

GLOBIGERINA SUBDIGITATA Carman, n. sp.
Plate 34, figs. 4, 5

Test trochoid, in early stages with very low spire, becoming nearly planispiral in the adult, perforate. Last few chambers greatly elongated, with blunt ends, with chamber walls parallel not tapering. Axis of these chambers joins test at tangential angle.

Holotype.—(Cushman Coll. No. 11969) from Cretaceous, Niobrara chalk of East flank of Centennial Syncline, West slope of Sheep Mountain, T. 15 N.; R. 77 W., East of Centennial, Wyoming. Diameter of holotype, 0.40 mm.

In its general shape this species reminds one of *G. digitata* found in the present ocean. The chambers are added in a tangential position that is characteristic even in early stages.

Genus GLOBIGERINELLA Cushman, 1927

GLOBIGERINELLA ASPERA (Ehrenberg)
Plate 34, fig. 6

Rotalia aspera EHRENBERG, Mikrogeologie, 1854, pl. 27, figs. 57, 58.
Phanerostomum asperum EHRENBERG, l. c., pl. 30, figs. 26 *a*, *b*.

Test planispiral, evolute, perforate, 7 chambers in last coil, last two chambers inflated.

Niobrara.

This is a common species in the Cretaceous of America as well as Europe.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA sp.
Plate 34, figs. 2 *a*, *b*

The small *Anomalina* figured here occurs rarely in the Benton and not in sufficient numbers so that it seemed specific identification was warranted.

RESEARCHES IN PALEONTOLOGY

Dr. Charles Schuchert, Yale University, has devoted most of his time during the past two years on the preparation of a book on the stratigraphy and paleogeography of North America. He estimates that it will require three years more to complete the work. In addition to this monumental study, Dr. Schuchert has published recently the following papers:

The so-called "Lower Silurian" fossils of Venezuela: Bull. Amer. Assoc. Petr. Geol., vol. 12, no. 9, pp. 951-952, 1928.

Review of the late Paleozoic formations and faunas, with special reference to the ice-age of Middle Permian time: Bull. Geol. Soc. America, vol. 39, pp. 769-886, 1928 (1929).

(With C. M. Le Vene) New names for brachiopod homonyms: Amer. Jour. Sci. (5), vol. 17, pp. 119-122, 1929.

Chamberlin's philosophy of correlations: Jour. Geol., vol. 37, pp. 328-340, 1929.

The geological history of the Antillean region: Bull. Geol. Soc. America.

Now in press:

(With C. M. Le Vene) Index and bibliography of brachiopod genera and their genotypes: Part 42 of *Fossilium Catalogus*, I, Animalia.

Dr. Junius Henderson of the Department of Geology of the University of Colorado has now finished a 600-page manuscript entitled "The Non-marine Fossil Mollusca of North America". It is hoped that arrangements can be made to have this valuable paper published in the near future.

Dr. J. J. Galloway and Dr. Charles Ryniker have ready for publication a paper on the foraminifera and ostracoda of the Atoka formation.

W. S. Adkins, of the Bureau of Economic Geology at Austin, Texas, is engaged in a study of rudistids of the Edwards formation of Texas, which he expects to publish shortly.

Dr. J. A. Cushman and Mrs. Esther R. Applin are preparing a paper on the micro-faunas and lithology of some well sections in South Dakota.

Dr. J. W. Beede has been spending the past year in research work at the University of Indiana, where he has completed for publication the following papers: "Permian Fusulinidae", "Classification of the Permian System", and "The Problems of the American Permian".

Dr. J. J. Galloway and Miss Margaret Morey have nearly completed a paper on Chiapas foraminifera.

Dr. Raymond Sidwell of the Department of Geology at Texas Technological College will have ready for publication in the fall a paper entitled "Fauna of the Colorado Series of Southwestern Wyoming".

A. S. Warthin, Jr., of the Department of Geology, Columbia University, is now completing a paper on the complete micro-fauna of three middle Pennsylvanian formations of Oklahoma.

John S. Cruse, paleontologist for Pure Oil Company, Houston, Texas, is engaged in a detailed study of the foraminifer, *Rotalia beccarii* (Linné) with special reference to its evolutionary changes and to the splitting of the species into varietal forms, as a means of identifying stratigraphic zones in the late Tertiary and Recent formations of the Gulf Coast.

Dr. Gayle Scott, professor of geology at Texas Christian University is spending the summer in a detailed study of the faunas and geology of the Lower Comanchean formations in the vicinity of Fort Worth, Texas.

The Arkansas Geological Survey has recently issued a bulletin entitled: "Upper Cretaceous Ostracoda of Arkansas", by Merle C. Israelsky.

Dr. J. Marvin Weller has recently completed, as report of Investigation No. 18 of the Illinois Geological Survey, a paper on the gastropod genus *Yvania*.

Dr. Wendell P. Woodring has completed his account of the mollusks of the Miocene Bowden formation of Jamaica. His latest contribution, "Miocene Mollusks from Bowden, Jamaica, Part II, Gastropods, and Discussion of Results" contains descriptions of 400

species of gastropods together with an account of the geology of the mollusks and a discussion of the age of the Bowden formation. This comprehensive monograph is issued by Carnegie Institution at Washington as Publication No. 385.

Dr. H. G. Schenck of Leland Stanford University and Mrs. Dorothy Palmer of Scripps Institution of Oceanography are completing a study of the astoria fauna (Miocene) of the state of Washington.

Mrs. Mildred A. Fenton of the University of Buffalo has recently published in the American Midland Naturalist a paper on *Lichenocrinus* from Black River formation.

Dr. Carroll Lane Fenton has a paper in the same journal on *Strophimena filitexta* Hall.

Dr. J. A. Cushman and Dr. Yoshiaki Ozawa have completed a "Monograph of the Polymorphinidae, Fossil and Recent" after two years' work together. There are 40 plates illustrating all the valid species.